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THE NOVEMBER SCIENTIFIC MONTHLY

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Elements of Astronomy. EDWARD ARTHUR FATH. Second edition. 323 pp. 212 illustrations. $3.00. New York, 1928.

A non-mathematical textbook for use in colleges and for the general reader. This second edition brings the material up to date of March, 1928. Eight star charts covering the entire sky and many new illustrations have been added.

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After forty years of study, observation and reflection on the subject of socialism, F. J. C. Hearnshaw in this book analyzes the nature of socialism, traces its origin and development, and criticizes its main principles and conclusions.

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THE SCIENTIFIC MONTHLY

NOVEMBER, 1928

THE PHYSIOLOGY OF THE DUCTLESS GLANDS

By Professor N. B. TAYLOR

DEPARTMENT OF PHYSIOLOGY, UNIVERSITY OF TORONTO

THIRTY years or so ago the study of the ductless glands was a field of practically virgin soil. If we should look into a text-book of physiology of that day we would find the subject disposed of in a very few words. Since then much has been learned and the work that has been done on these hitherto little known glands is enormous. Each year, literally millions of hours of laboratory and clinical work are performed and thousands of papers are written upon the subject. Unfortunately, the great bulk of this work is quite barren of any real or lasting value, for just as a ton of rock must be mined and milled in order to secure an ounce of gold, or several tons of pitchblende be treated to obtain a gram or two of radium, so an immense amount of work must be done by the laboratory mills in order to recover a few grains of truth. We read, from time to time, in the daily papers, in semi-scientific publications and in the advertising literature of some of the drug houses, sensational and glowing accounts of the activities of these glands. But most of these glittering tales are misleading and arise from nothing more genuine than a very vivid imagination.

The qualifying or negative word "ductless" implies that these glands are peculiar and distinctive in being without ducts. It implies also that they were discovered later than the more usual type of gland with ducts. It suggests something new and out of the ordinary.

A word first with regard to the usual type of gland. These have been familiar to anatomists and physiologists for hundreds of years. Each is composed of a mass of cells arranged in one or other definite pattern so as to form myriads of tiny spherical cavities. On the outside of the wall of each cavity are blood vessels so that one side of each cell is practically in contact with the blood. From the blood flowing past their doors the cells take what chemical materials they require, and with these raw materials manufacture in some mysterious way a very complex substance which they pour into the bowl-like cavities. This material, the gland's secretion, passes into fine hair-like tubes which lead, one from each of the numberless cavities. These fine tubes are the ducts. They join with one another and form larger ducts. These in turn, join to form larger ones, until finally the secretion finds its way into one or two large tubes which open into one of the body cavities, the mouth or intestine, for instance. The arrangement of the ducts is like the stem system of a bunch of grapes —the hollow masses of cells representing the grapes.

Some, such as the tear glands, the sweat or mammary glands, empty upon the surface of the body. Since the activities of many of these glands are as-

sociated with experiences of every-day life—crying, sweating, salivation, etc.—it is not surprising that they should have been known for so long. They are characterized by two main features. Their secretions are collected by ducts and through these they are poured either into one of the body cavities or upon the surface of the body. In short, they are glands of external secretion.

The ductless glands pour their secretions directly into the blood stream. None of their secretions pass outside of the body. They are on this account also called the glands of internal secretion, endocrine glands or simply the endocrines. Their secretions are also known as hormones. The cells of these glands take in their raw materials by the front door—the arteries—and after fabricating a most powerful chemical material, turn the finished product out at the back door—the veins. Thence the hormone is purveyed to all parts of the body.

These glands are little chemical factories of a marvelous ingenuity; and what apparently miraculous effects their concoctions can bring about! Nothing more wonderful was ever dreamed of by the ancient alchemists with their elixirs and potions. It is the action of one of these secretions that paints the plumage of the male bird in such brilliant colors and also prompts its song. Others cause the growth of bone and direct the development of stature along normal lines—overactivity of this or underactivity of that, and a giant or a dwarf is made. Others influence various psychic processes—instinct, emotions and intelligence. In order that mind and body shall be healthy and normal all the glands must pour their secretions into the blood stream in proper and due proportions—none must be a sluggard, nor yet overzealous in performing its duties.

Some of the glands are of such a size and prominence that they could not escape the notice of the ancient philosophers. Their uses were pondered and speculated upon and many fanciful conjectures were made to account for their presence in the body. But their true functions were undreamed of—they were beyond even the imagination of those days.

Before the discovery of their true functions the control of the various parts of the body was believed to be vested entirely in the nervous system. It was the master tissue. It was the headquarters staff which issued its orders to the various organs and its authority was believed to be supreme. With the discovery of the ductless glands, an entirely new type of control of the bodily function was brought to light. Their influence, if less evident than that of the nervous system, is nevertheless just as important in their own particular sphere.

The *internal secretions have authority* over slowly moving processes, such as the development of particular organs, the growth of the body as a whole and the metabolism of food materials—processes measured by hours, months or years; whereas the nervous system presides over those rapid processes of thought—muscular movement and the external secretion of glands—processes measured by fractions of seconds (or minutes).

There are many sides from which the functions of the ductless glands may be viewed. I might, for instance, discuss them in their relation to character or to personality or heredity—or even to morality or criminality! And there is little doubt but that they have an influence upon some or all of these, but so far science has been unable to place its finger upon anything very definite. Or, I might discuss them in their relation to our "decline into the vale of years," as the poet with such a pleasant euphemism refers to old age. But this side of the question, which has received a great deal of attention in France and on the Continent, is so befogged by pseudo-science and beset with quackery that I would rather leave it alone. I

prefer to take up more definite and known effects, effects that can be proved by direct observation or experiment, and to avoid the more speculative side of the subject, which after all is no stranger than the truth.

Several methods have been and are still made use of to unravel the mysteries of the endocrine glands. In the first place, extracts of the gland tissue may be prepared which may then be injected into animals and a study made of their effects. Secondly, particular glands may be removed from animals and the subsequent life history of these animals watched, taking careful notice of their subsequent development, growth or any unusual symptom. Or, thirdly, we may study diseases in the human subject in whom a particular gland is known to be deficient or overactive.

I shall consider first a gland with which every one to some extent is familiar. This is the thyroid, which lies beneath the muscles of the neck embracing the larynx. When enlarged inordinately, it constitutes the condition known as goiter. All the methods of investigation which I have mentioned were used in the study of the thyroid before any clear idea of its functions was formed.

A certain slight enlargement of the thyroid above the average is an adjunct to feminine beauty. Indeed, one of the older anatomists thought that therein lay its premier function. It gives a pleasing fulness—a roundness to the contours of the neck, no doubt. This fact was not lost sight of by many of the old masters who carried the idea to extremes and painted their maidens with necks which verged upon the goitrous.

The thyroid's greatest power for beauty, however, lies not in its size or its shape, but in its secretion. Every one who has ever seen one of those unfortunates who, from birth or shortly after, had been deprived of his thyroid secretion will know what I mean.

In Switzerland, in the valleys of the Alps, there was to be seen a type of dwarf known as a cretin. A cretin is the direct result of the absence or extreme deficiency of the thyroid hormone. These individuals were truly the most pitiable and grotesque parodies on mankind. They were stunted and deformed in stature and mentally defective or quite imbecilic. Their features were misshapen and flabby. The brow was low, the bridge of the nose depressed and the nostrils wide; the tongue appeared too large for the mouth, which was coarsely moulded. The skin was thick and the hair dry and sparse. I think the description of Caliban must have been inspired by the poet having at one time seen a cretin. Cretins never grew up, but remained for the rest of their lives children in mind and body. Yet, had they been Peter Pans—attractive, happy and intelligent children—all might have been well. But no, they dragged their uncouth bodies through a drab existence, a burden to themselves and their families—or a charge upon the community. The word "cretin" is simply a corruption of the French for "Christian"—*chrétien*—used in the same sense as the English words "innocent" or "simple" are applied to the feeble-minded.

Though cretins were more common in Switzerland than in other parts of Europe, they were by no means confined to that country. Osler, "within a few years," as he says, was able to collect the histories of fifty-eight cases in Canada and the United States. Cretinism was at one time not uncommon in England, especially in Derbyshire. But it was in the valleys of the Alps, of the Pyrenees, in the Tyrol and in the Himalayas that it was seen most frequently.

It was not until the gland was removed in young animals that a clue to the cause of the condition was uncovered. Sir Victor Horsley, the famous London surgeon, performed this operation upon monkeys, and showed that the symptoms which followed were prac-

tically identical with human cretinism. Through this work the responsibility for the cretin was definitely fastened upon the thyroid. This was the gland at fault.

The questions had still to be answered: "Why is cretinism common in certain regions and practically unknown in others?" "Why does the gland fail to perform its proper functions?" The most generally accepted answer to these questions was that the drinking water was at fault. Even as late as 1910 Sir Hector Mackenzie, a pioneer in this field, wrote, "the most potent cause is the water used for drinking purposes." He admitted that the particular something in the water which affected the thyroid in this way was unknown. Later, however, it was thought to be an infecting organism (McCarrison).

Without going further into detail, I may say that the question has at last been settled. It is not due to something in the water that should not be there but to something that is not there which should be there, if I may so express it. It is due to a dearth of iodine in water and food. For this knowledge we are indebted to Marine, of Cleveland, who showed a few years ago that thyroid disease in brook trout could be cured by the addition of minute amounts of iodine to the water in which they swam.

That explains why cretins are practically never seen on the seacoast. The sea is an inexhaustible storehouse for iodine, which finds its way into the food and the drinking water of the coast's inhabitants. It is always in inland territories that thyroid deficiency is seen—particularly in the mountains and the high land, since they, as a rule, are farther removed from the iodine supplies. Analyses of the soils of goitrous districts have shown a marked scarcity of iodine. Chatin, a Swiss, pointed this out seventy-five years ago, but no attention was paid to the observation.

The thyroid must have iodine in order to manufacture its secretion. Without this element it struggles on as best it can, but it can not make bricks without straw. It becomes enlarged, yet the enlargement is made up, to a large extent, of worthless tissue with its spaces filled with an impotent fluid. The important glandular tissue has degenerated, and, though the gland is of greater bulk, it is a fraud and is quite incapable of manufacturing an active secretion. We would also find that such a gland was almost barren of iodine, or at any rate, held but a fraction of the normal amount. It is now an axiom of thyroid pathology that the larger the gland the less is the iodine which it contains.

This is the usual way in which cretinism occurs—following goiter, which destroys the functional activity of the gland. But in rare instances thyroid function may be destroyed by some acute disease of childhood—or rarer still, some unlucky individual may be born without one.

A similar condition, and one having the same cause, may arise in adult life. It is known as myxedema and is essentially the same as cretinism. There can, of course, be no stunting of the stature or mal-development of the bones, since it appears after the period of growth. Myxedema was common in the same regions where cretins were found.

In my discussion of cretinism and myxedema, I have deliberately kept to the past tense, for the very good reason that they are practically things of the past. Medical science in its progress has swept them from its path. We might travel through the Alps to-day, and I do not think that we should see a single cretin, unless it was a case of long standing.

Cretins and myxedematous subjects owe their changed fortunes to an English physician, Dr. George Murray, now emeritus professor of medicine at Manchester. It occurred to this investigator to extract the thyroid glands of sheep

with glycerine and to inject this into the subjects of thyroid deficiency. It is interesting to recall how this idea first came to Murray. He read of an operation performed by two foreign surgeons, Bettencourt and Serrano, in which they had acted upon the suggestion of Sir Victor Horsley and grafted a portion of a sheep's thyroid beneath the skin of a victim of thyroid deficiency. They reported an improvement in the condition. Murray says, "this observation indicated to me that the gland carried on its functions by means of an internal secretion." He, therefore, concluded that it might be possible to extract this secretion from the glands of animals and that it might serve as a suitable substitute for the secretion that was lacking. In 1891 he reported the results of his first trials with the extract.

Of all the discoveries in the field of medicine, this was one of the most brilliant. The extract fulfilled the hopes of even the most sanguine. Its success was complete. It was able within a remarkably short time to conquer all the symptoms of thyroid deficiency in the adult—that is, myxedema.

His success with the cretin depended upon how long the condition had existed before treatment had been commenced. Obviously, not such great benefits could be expected in a case which had existed for years where brain, bone and muscle had been confirmed in their abnormal state. Yet even in these the improvement was often very striking. But in the early cases the effects appeared to be little short of miraculous. No potion brewed in magic cauldron ever produced a greater change than did Murray's extract. As though enchanted, the stunted and gnome-like body of the cretin grew to normal proportions. The ugly mask fell from the face, and the limbs took on the human grace which Nature had hitherto denied them. But, greatest benefit of all, the light of reason returned to the clouded mind, and in a short time these apparently hopeless imbeciles were turned into happy and intelligent children. It is no longer necessary to inject the extract, for it can now be taken in tablets. To-day there should be no cretins under forty years of age. If one younger than this should be seen he is a sad reproach to some one —whether physician or parent—who has failed to bring to this blighted one the certain cure which is ready at hand.

There is another reason why cretins are rare to-day, and that is, the occurrence of goiter is prevented. The cause is removed. Iodine is added to the drinking water or the food, or given in small doses a few times a year to the children of the Swiss cantons and other regions where goiter is prevalent.

There is little doubt, then, of one function of the thyroid gland. It controls the growth and the development of both body and mind. It takes iodine and other materials from the blood and manufactures a secretion or hormone which produces these effects.

In order to bring further conviction, I shall cite a very interesting experiment that was carried out a few years ago upon tadpoles—ordinary pollywogs, whose destiny is, as you know, to grow into frogs.

A group of tadpoles which had been hatched from the same batch of eggs a short time previously was placed in a small aquarium. A number of these creatures were operated upon, and their thyroids removed—rather small subjects, you might think, for a major operation, and rather poor risks, too. But a certain proportion of them made a good recovery and continued to swim about after their convalescence, just like a number of their brothers who had been allowed to keep their thyroids.

The animals without thyroids, however, never grew into frogs. The experimenter, with his scalpel, had shaped their destinies. The joys of frogdom were not for them. Never were they to

spring from slimy pools to breathe the air or bask in sunshine upon a lily pad. They remained pollywogs for the rest of their lives. They were the counterparts of human cretins in so far as body growth and development went. Since their mentality is scarcely of a measurable quantity, no one can say how they progressed in that direction. They can not be subjected to intelligence tests, nor do we know what their brothers thought of them; so that side of the question must be left to the imagination. Their normal brothers, which were kept under precisely the same conditions, lost their gills and tails, grew arms and legs and matured into frogs in the usual way and in the usual length of time—two and a half to three months.

If thyroid extract was given to the cretinoid tadpoles—a small quantity merely dropped into the water in which they swam, or fresh thyroid tissue fed to them—they commenced to develop in the usual way and in due time were hopping about, perfectly normal frogs.

On the other hand, when extract was added to the water in which the normal tadpoles lived—those which were not deprived of their thyroids—they developed into frogs ahead of time. Their development was speeded up. The gills and tail disappeared and the limbs grew out in about a third of the usual time. It can easily be understood why this should be, for their bodies were receiving an excessive amount of thyroid principle—that manufactured by their own thyroids plus that given to them by the experimenter.

Thyroid function has been tested out on another close relative of the frog family. In Mexican waters there is a strange creature known as the axolotl. It is considered quite a delicacy by the Mexicans, though I think that if you ever saw one its gastronomic possibilities would not interest you. The axolotl is a sort of halfway house along the evolutionary path, between a fish and a frog. It looks like a huge tadpole—for it is several inches long—that had started out to be a frog but thought better of it, and remained a grotesque looking object with gills, a finned tail, square head and short fore and hind limbs. This is the usual adult form of these creatures, they breed in this form, many of them never developing into land animals and a few others doing so very, very slowly. If they are fed upon beef thyroid, even one or two meals is enough, they develop into air-breathing animals. They lose their gills and tail fin and develop air-breathing organs. The head becomes oval and the eyes prominent.

Here is an instance in which an animal—forsaken, as it were, at a certain wayside station in the evolutionary journey—has been brought a step further by an internal secretion. I promised not to speculate, but I can not help but wonder just how important a part the ductless glands have played in the evolutionary process.

The thyroid has another entirely different duty to perform, besides those mentioned before. Its hormone is to the body as a forced draught is to a furnace. It fans the fires of life. You all know that the body shows a very real likeness to a furnace or an internal combustion engine. Its muscles consume fuel and in doing so use oxygen and give out carbon dioxide, just as any combustion engine does. Energy is liberated, heat is produced and work is done. Thyroid extract increases the combustion in the muscles. More heat is produced with extract than without. The fire in each cell burns more fiercely. The metabolism—as the physiologists say—is increased.

In those suffering from thyroid lack the fires are dampened down. They glow dully, not brightly as they should—metabolism is lowered. The metabolism may be altered 50 per cent. either way by an increase or a decrease in thyroid secretion. On this account, very

serious effects will result if a normal individual should take thyroid extract for any length of time, for in that case the administered dose added to the natural secretion would increase the combustion within the body to a dangerous degree. Sometimes the thyroid has an exaggerated sense of what is required of it and manufactures more of its very potent secretion than the body needs. The symptoms of overdosage soon become evident. I shall not dwell upon the details of this condition. There is, of course, increased metabolism which requires special methods for its detection. The most evident feature is protruding eyeballs, though it is by no means certain that this symptom can be laid at the thyroid's door. Indeed, there is much evidence that it can not.

Ever since Murray showed that the functions of the thyroid were due to an internal secretion and that this could be extracted, many investigators have endeavored to isolate the active principle, or essence, one might say, from the more or less crude extract which he first obtained. As a result it was not long before some knowledge of the chemical nature of the active principle was gained. A few years ago this principle was obtained in pure form by Kendal, of Rochester, Minnesota. He "dubbed" it thyroxin. It contains iodine, about 60 per cent., combined with certain well-known organic materials. The iodine radical is believed to be responsible for the growth-promoting functions of the thyroid, and part of the organic radical (pyrrol) for the effect upon metabolism. For, if the iodine portion be broken off, the remainder still increases the metabolic rate, yet it has now lost its influence upon the metamorphosis of tadpoles. On the other hand, if the pyrrol group alone is broken off, the material exerts its usual effect upon the tadpole.

Harrington, in England, within the last couple of years, has actually succeeded in manufacturing this material in the laboratory—that is, in producing it artificially from its chemical constituents. It has all the physiological properties of the natural product. But it, as well as Kendal's thyroxin, is many times more powerful than Murray's crude extract; an almost insignificant amount will produce the most profound effects. It may be looked upon as the quintessence of the thyroid juice—a superextract.

THE pituitary is another ductless gland which has just as important duties to perform as the thyroid. But it is only a fraction of the size of the thyroid. In man it is scarcely larger than a cherry and lies like an Atlas at the base of the brain with the huge hemispheres heaped above it. And like Atlas, its responsibilities are great, for, if it is removed or destroyed, the whole body is thrown into chaos. It is cast into an abyss from which all the gods are powerless to raise it; death follows inevitably and swiftly. As may be seen, this gland is composed of two parts which, though they are in intimate contact with one another, have entirely different functions to perform. The two divisions are spoken of as lobes, the anterior and the posterior.

The pituitary has been a puzzle since ancient times. It is only within recent years that a glimpse of its true functions has been allowed us. Since it lay on the floor of the skull not far from the root of the nose, some of the ancient writers thought that it existed for the purpose of secreting mucus into the nostrils—indeed, that was how it got its name; pituita, mucus and phlegm were cognate terms in the middle ages. Others, with perhaps more poetry in their make-up, thought that it was the throne of the soul.

As I have said already, one of the main avenues of approach to an understanding of the internal secretions has been through a study of their disorders in the human subject. The first step

toward our present-day conceptions of pituitary function was made by the French physician, Pierre Marie. It was he who first described a condition characterized by overgrowth of the bones of the face, hands and feet. The enlargement of the facial bones was seen particularly in the ridges above the eyes, in the nose and lower jaw. In some cases reported by Marie this member measured 18 inches from ear to ear and the chin was some 4 inches deep. The soft tissues also were thickened, the combination of fleshy and bony overgrowth producing extreme coarsening of the features. This in many cases amounted to grotesque ugliness. The bones of the hands and feet, especially the former, showed a similar overgrowth. This was no moderate enlargement, for the hand of one of these individuals might be double the size of that of a normal person of the same height.

Marie ascribed this condition to disordered function of the pituitary and called it acromegaly, which any Greek scholar would at once tell us simply meant "big extremities." Marie thought that it was the result of depression of the pituitary function, but we know now that it is due to just the reverse—increased secretion by this gland. The disease comes on more or less gradually, but the changed facial expression is rendered very noticeable if a photograph of the subject, taken perhaps five or ten years previously, be compared with the same person in the flesh.

The disease, if it progresses, is invariably fatal, and in all these cases an enlargement of the anterior part of the pituitary has been found after death. There is no doubt, then, that it is this part of the pituitary which is at fault.

Sir Arthur Keith, the noted anatomist and anthropologist, has thrown an interesting sidelight on this condition. While classifying a collection of skulls in the museum of the Royal College of Surgeons in London, he came across one that was undoubtedly acromegalic. He at once recognized the prominence of the bone above the eye sockets, the massiveness and elongation of the lower jaw and the general enlargement of the face area of this skull. The other stigmata of acromegaly were unmistakable. But what struck him most was the remarkable resemblance which this skull bore to the skull of Neanderthal man—one of the earlier of the prehistoric men in Europe. By careful measurements of the two skulls—the acromegalic modern and the normal prehistoric—he found that each showed the same essential characteristics. Upon the skulls of the higher apes are also seen many of the features of the acromegalic skull.

These facts prompt the question: Is the pituitary of man of to-day less active than was that of prehistoric man? In other words, was a secretion which would be considered excessive and pathological to-day normal and physiological to Neanderthal man? We are also tempted to ask whether a gradual lowering of pituitary function has been an aid or an important factor in the evolution of the facial and other skeletal characteristics of modern man? These questions may be asked, but no one, I think, has been bold enough to answer them dogmatically. And there is one great difficulty in considering these suggestions. We shall show in a moment that the growth-promoting power of the pituitary is not confined to the bones of the face and extremities, but extends to all the bones of the body. We would, therefore, expect—if the gland had the effect which Sir Arthur suggests—that the prehistoric man with the beetling brows and the massive jaw would have been a giant. But he was nothing of the sort; he was in fact below the average height of modern man.

Acromegaly is a disorder of the anterior lobe of the pituitary in adult life, that is, after the normal period of growth. But this part of the pituitary

may suffer the same disorder in earlier life, that is, during the growing period. The gland may, just as in the case of acromegaly, become too zealous and secrete an inordinate quantity of its very powerful hormone at this time. When it does, it is not only the bones of the face and extremities which overgrow, but all the bones of the body are urged into an extraordinary overdevelopment. In this way are giants made. Those men of tremendous stature who earn their livelihoods in circus sideshows are instances of overactive pituitary glands. Some of these giants reach the "altitude" of eight or nine feet. They would knock their heads against the ceilings in the modern Toronto house and would need to bend nearly double to pass through a doorway. The tallest which I have seen reported was a Finn, nine feet five inches. But there has been a Chinese giant reported who was eight feet one inch, and an American recorded by Dr. Harvey Cushing as over eight feet two inches. These are the extreme cases, but there are many degrees of giantism or gigantism, as the condition is called. A certain French baron some years ago sought by encouraging the inter-marriage of giants and giantesses of this type to produce a race of supermen, but the experiment, for which a million francs was subscribed, proved a dismal failure. The gigantic parents had average sized offspring. And this is a characteristic of pituitary giantism. The giants are usually the children of normal parents and they themselves have normal children.

The pituitary by these excesses—acromegaly and gigantism—has revealed itself. There is every reason to believe that its physiological function is to urge the growing bone, within normal limits.

If the pituitary can increase its output above the normal and produce giants, the question naturally arises whether it ever fails to manufacture enough of its hormone and produce dwarfs? It does, and there are two kinds of dwarf which may result from a deficient pituitary secretion. Only one of these is caused by deficiency of the anterior lobe alone. He resembles the midget, but differs in certain essential features from that popular attraction of the sideshows. The midget remains unexplained; he may be a pituitary case, but there is no evidence that he is. The true anterior lobe dwarf is a rather quaint little person. He (or she) is perfectly proportioned, delicately formed and usually of a pleasing appearance. To the casual observer he appears normal in every way, except in size, and his intelligence is usually of the average grade, though in some cases it is below the normal. They are men and women in miniature—adult figures, seen as it were through the wrong end of the telescope, for their bodies are never proportioned upon the plan of the child, that is, with relatively large heads. Nor are their facial features childlike.

Very frequently the posterior lobe as well as the anterior is deficient. The disorder, then, is one of the pituitary as a whole. There will be seen a combination—a mixture of effects, some caused by one lobe, some by the other.

Before these combined effects can be described, the functions of the posterior lobe must be outlined. The duties of this part of the gland are not so clear as those of the anterior. True, an extract may be obtained from it which produces immediate and very definite effects when injected into an animal. It causes, for instance, a rise in the blood pressure and induces contractions of the muscular walls of various organs of the body. But whether they are part of a true physiological function or merely effects produced through artificial methods of extraction can not be said.

There is no evidence that the posterior lobe is concerned in any way with the development and growth of the bones.

There is one function, however, of which there seems to be no doubt. It is concerned with the disposal of sugar by the body. When its secretion is produced in insufficient amount, there is a remarkable increase in the quantity of sugar which the body can use. If a normal person takes a large quantity of sugar it is not all utilized by the body cells. The excess can be found in the blood and is later excreted. The subject of posterior lobe deficiency can utilize several times that which the normal individual can use. It would appear that this excessive utilization can not be accounted for by increased *combustion* of the sugar and consequently by a greater production of heat. For these subjects have a body temperature that is lower than the normal, and the general metabolism is actually depressed. The excess sugar is evidently used for the formation of fat, since the outstanding feature of these subjects is the great overdevelopment of fatty tissue. Injections of an extract of the posterior lobe produce the opposite effect—a reduction in the body's ability to use sugar.

Pituitary disorders of this nature are not infrequently seen in children. Many children, as we know, have a tendency to increase their fatty tissue at a certain age, and this may be due to a normal variation of the posterior lobe hormone. But these individuals with posterior lobe deficiency are not just ordinary fat children. Their fatness is really extraordinary; they are veritable roly-polies and present a striking appearance. They have often a voracious appetite and have, even for children, an inordinate longing for sweets of all kinds. They are, as a rule, somewhat below par mentally, progress slowly at school and show an unchildlike lethargy—ready to sleep at any time. Dickens' Fat Boy, I think, must have been a pituitary case; and the little fat boy whom many of you may have seen in the movies, as a member of that humorous group of children known as "the gang," has, I think, if the truth were known, a pituitary whose posterior lobe is not quite doing its duty. Great obesity may result from posterior lobe deficiency in adults also, and the fat woman of the circus is in many cases, no doubt, an example of this condition. Indeed, the vagaries of the pituitary have proved a great source of profit for the circus proprietor.

When there is a deficiency of the anterior lobe accompanying the deficiency of the posterior lobe, there is a combination of the effects characteristic of both parts of the pituitary. Arrested growth, added to the extreme obesity, produces a remarkable type of dwarf. His length and breadth approach equality. Gigantism with obesity will also occur if overactivity of the anterior lobe be associated with deficiency of the posterior.

Experimental

All these instances go to show the direction in which the activities of the pituitary lie. If disorders of its function produce these abnormalities, it is, I think, logical to assume that its physiological function is to influence the growth of the body within normal limits (anterior part) and to furnish a hormone which controls in some way or other the conversion of sugar into fat (posterior part). Until recent years, little support for these conclusions, arrived at from the study of human cases, could be obtained from animal experimentation. The other two methods of approach—use of extracts and removal of the gland—failed to produce decisive results. Recently, however, Evans and Smith, of the University of California, have been able to show in a truly spectacular fashion the profound effect which the anterior lobe has upon growth. They have been able to prepare an extract of the anterior lobe which has this effect. The experiments were carried out in this way: Pituitary glands (anterior lobe) of the ox were minced and extracted with

salty water. The extract obtained in this simple way was then injected into young white rats over a period of several weeks. Other rats of the same litter were kept under precisely the same conditions and received the same food, but were not injected with extract. These untreated rats served as standards or controls, as they are technically called, to which the injected rats could be compared.

The period of growth of the normal laboratory rat is now well known. It is from 150 to 180 days. At the end of this time it has reached the adult form and size and ceases to grow further. The control rats followed this normal course. The treated rats, that is, those injected with the extract, did not cease to grow when the end of this period was reached, but continued to grow for several weeks afterwards. They finally developed into huge, giant rats. Though they were not, perhaps, as large as the rats that Gulliver adventured with in Brobdingnag, they were at least 60 per cent., and in some cases 100 per cent., larger than their brothers and sisters of the same litter which had received no extract.

The other side of the picture was also outlined by experiment, that is to say, depression of the pituitary function produced the reverse effects—retarded growth. On account of the small size of the pituitary in the rat, it is impossible to destroy one part of the gland without injuring or destroying more or less of the other part as well. There is also the danger of damaging too severely the anterior lobe, which is essential to life. It was, therefore, impossible to produce pure effects of one or the other lobe. The effects were what might have been expected from partial destruction and consequent deficiency of both lobes. The animals became very fat and failed to grow to normal size. They corresponded very closely to the type of dwarfs already described for human subjects, as a result of deficiency of both lobes. These animals, however, usually showed the obesity more than the dwarfing; they were so rotund that they resembled nothing so much as little balls of cotton wool.

Before leaving the subject of the pituitary I must speak of another strange effect which its secretion has upon certain members of the amphibian and reptile families. Many of you no doubt have been fascinated by the way in which some of these creatures, such as the tree toad and certain varieties of lizard, particularly the chameleon, apparently change the color of their skins to match the background upon which they lie or cling. Many fish, also, are endowed with this ability. Even the common frog is of a darker tint in subdued light or on a dark background than it is in bright sunshine, where it appears to become "bleached" to a much lighter shade of green or yellow.

The frog's skin, as you know, is not of a solid color, but is marked with dark spots or blotches which overlie a light greenish yellow ground. This mottling is particularly well marked in one species—the leopard frog. If the dark spots are examined beneath the microscope they will be found to be made up of groups of cells with many branching arms and containing granules of a dark pigment. These cells expand in the dark or in dim light and contract in bright light. Or I should say, rather, that the pigment collects near the center of the cell when the light is bright, but streams throughout the whole cell and into its branching arms when the frog is in darkness. So the blotches become larger and take up a greater part of the skin pattern, and less of the underlying green or yellow pigment of the skin shows through. This action of the cells of the frog's skin was a puzzle to biologists for years. They thought that nerves must be concerned in the reaction, yet this could not be demonstrated with general satisfaction. One competent observer, for instance, was convinced that the reactions were carried

out through the sense of touch in the skin of the toes. For, he said, when the toes were rendered anesthetic by cocaine, the responses did not occur. He thought that the textural qualities—hardness, roughness, etc., of various materials, such as stone, grass, wood, earth, etc., upon which the animal rested, produced color reactions in the pigment cells corresponding to the color of these materials. In other words, the nerves established an association between the texture or any other "touchable" quality of a material and its color. This theory, on the face of it, seemed improbable, and it is not at present entertained.

If a few tadpoles be taken and their pituitaries removed—this can be done quite easily in this creature, for the gland lies in an accessible position beneath the upper surface of the head—very soon we should find that the animals had lost their natural dark color and appeared as mere silvery ghosts of their former selves. This suggests to us at once that the same thing which bleaches the tadpole also bleaches the frog. Does the lack of pituitary secretion cause the pigment granules to retreat to the center of the cells, and does the presence of the hormone in the blood cause them to spread throughout the cell-body? We can easily put this suggestion to the test. If a frog be injected with an extract of the posterior lobe, its skin within a moment or two becomes coal black. After removal of the pituitary, on the other hand, the frog is unable to alter the color scheme of its skin when the illumination of its surroundings is altered. There is little doubt, then, of the action of this portion of the pituitary upon the pigment cells of the frog. If the eyes of a normal frog are covered with some opaque material, the color reaction does not occur.

Now we can form a picture of the mechanism by which the animals change their tinting according to the light. If the frog is in a bright light or upon a light background the retina is stimulated by the rays of light. Impulses pass along the optic nerves to the brain, and some of these impulses are sidetracked to the pituitary's posterior lobe and its secretion is suppressed. The suppression persists so long as the rays of light are entering the eyes. The pigment cells, however, do not at once become pale, for the secretion which had been circulating in the blood, and which keeps the cells expanded, must first be used up. This takes a certain time, but as soon as it is complete the cells appear to shrink, and a sickly greenish yellow pallor creeps over the amphibian skin. In this way does the frog—leopard or other variety—change his spots; but the Ethiopian can not change his skin, for no corresponding reactions have been shown to occur in man or in any of the higher animals.

Limited space permits me to consider only two ductless glands. I have chosen these two because more is known of them than of others which I have not touched upon. I might, for instance, have discussed the parathyroids—those tiny glands which lie beneath the thyroid. They are essential to health and, indeed, to life itself, though even in an ox they are no larger than a bean. They govern the amount of calcium in the blood. If they are removed the calcium is reduced, and an extract prepared from them when injected into an animal causes the calcium to rise.

Or I might have taken up the adrenal glands, which lie near the kidneys and are believed by some to enhance the reactions of the primitive emotions—hate, fear, anger, etc. There are also those glands which have been shown to exert such influence upon the development of the secondary characteristics of sex, such as the plumage of birds and the antlers of stags. There are also the pineal gland and the thymus, the one lying deep in the brain, the other deep in the chest, and both shrouded in the deepest

mystery. There is also the pancreas, which pours insulin into the blood stream, but the study of this hormone is a very large subject in itself.

I have treated the glands of which I have spoken as though they were quite independent one of the other. This is unavoidable, because this is the way in which they have been studied, and this is the way in which most of the information regarding them has been gained. Yet there is no doubt that their actions are very closely related one with another and that it is purely artificial to study them in water-tight compartments. It is, however, at the present time, impossible to do otherwise.

We should look upon the secretions of the ductless glands rather, I think, as forming with the blood a suitable environment—an appropriate fluid medium to bathe the cells of the tissues. When all secretions are present in their correct proportions the cells are healthy, they flourish and grow normally. If, on the other hand, one or other constituent of this nicely balanced mixture be present in reduced or excessive proportion, the environment becomes unsuitable and the cells suffer. Their development along the particular paths which hereditary impulses direct them is thwarted, and abnormalities result.

In order that there shall be physiological harmony, each endocrine gland must play its part in tune with its fellows.

COUNTING ATOMS AND ELECTRONS[1]

By Dr. L. F. CURTISS
U. S. BUREAU OF STANDARDS

IN the development of the subject of atomic physics, information is frequently necessary which can only be obtained from the study of individual atomic processes. Although much of our present knowledge is based on investigations of atomic aggregates, and conclusions have been drawn from the results which represent the average of millions of individual reactions, this method does not always give the information required, nor is it always safe to deduce what a single atom may do from the actions of atoms *en masse*. In fact, most of the important experiments which opened the way to what might be termed modern atomic physics dealt with individual atoms. As a striking example may be mentioned the well-known experiments on deflections of α-rays when passing through solids, performed by Sir Ernest Rutherford by the scintillation method. By counting the scintillation of individual α-particles on a zinc blende screen he was able to observe the behavior of individual particles and to show conclusively that the great preponderance of the mass of the atom was in a very small region near the center. This marks the beginning of course of the nuclear theory of atomic structure which still forms the foundation of all atomic speculation regardless of the manner in which these speculations are developed.

With each new development in atomic theory the importance of methods of this kind grows. It is therefore desirable to give special attention to such means of study. In addition to the scintillation method mentioned above for counting α-particles, there exist at present only two other ways in which observations of this kind may be made. One is the cloud-chamber originated by C. T. R. Wilson, and the other the electrical counter devised by Geiger. Although the scintillation method only permits a counting of the number of α-particles which strike it, the cloud-chamber makes the whole path of the α-particles visible, which has great advantages. Unfortunately the chamber only makes visible those processes which occur within about one one thousandth of a second and this imposes certain limitations on its use. The Geiger counter is very similar in its use to the zinc sulphide screen of the scintillation method but does not require a darkened room and will also count β-particles, *i.e.*, swiftly moving electrons. It also may be arranged to be self-registering so that permanent records of its count may be made automatically.

It may be appreciated from the above brief summary of these methods that the Geiger counter is capable of many important applications. However, its use is attended by several serious handicaps. One is that very little or nothing has heretofore been known regarding the real nature of its action. This has led to cut-and-try methods for producing working counting chambers, which were not always reliable. Even under best conditions great care and patience are required to avoid spurious effects which may vitiate the whole experiment.

[1] A more technical discussion of the subject will be found in a paper in the June issue of the *Physical Review* by the author. The present article is published with the approval of the director of the Bureau of Standards, Department of Commerce.

In view of this situation there is need of improvement in the counter which can only be accomplished when more is known about its operation. I wish now to describe some attempts to determine the essential conditions for a sensitive counter. The results have given some interesting information which leads to a better understanding of the nature of the action of the counter and which may lead to considerable improvement.

For the benefit of those who are not familiar with the Geiger counter, a brief description of its construction and use may not be out of place before we begin to discuss the experiments. Essentially in its usual form the counter consists of a cylindrical metal tube, closed at one end save for a small hole to permit α- or β-particles to enter. An insulating stopper fits the other end and supports axially the "point" which consists usually of a finely sharpened steel or platinum needle, occasionally with a minute ball fused on the end. Fig. 1 shows a diagram of such a counter. In use the walls of the counting chamber are charged to a constant potential of from one thousand to two thousand volts, depending on the size of the chamber, the nature of the point and its distance from the face of the chamber. It is customary to connect the chamber walls with the positive terminal of the battery, but it may be operated with the potential reversed, as will be discussed later. The point is connected to some sensitive detecting device such as a string electrometer or a vacuum-tube amplifier. When properly adjusted with a suitably prepared point, a "kick" of a string electrometer is obtained for each α-particle that enters the chamber through the opening in the front. This means that in some way the α-particle starts an ionization current between the wall of the chamber and the point, causing the latter to charge up. However, this current once started almost instantaneously stops and the

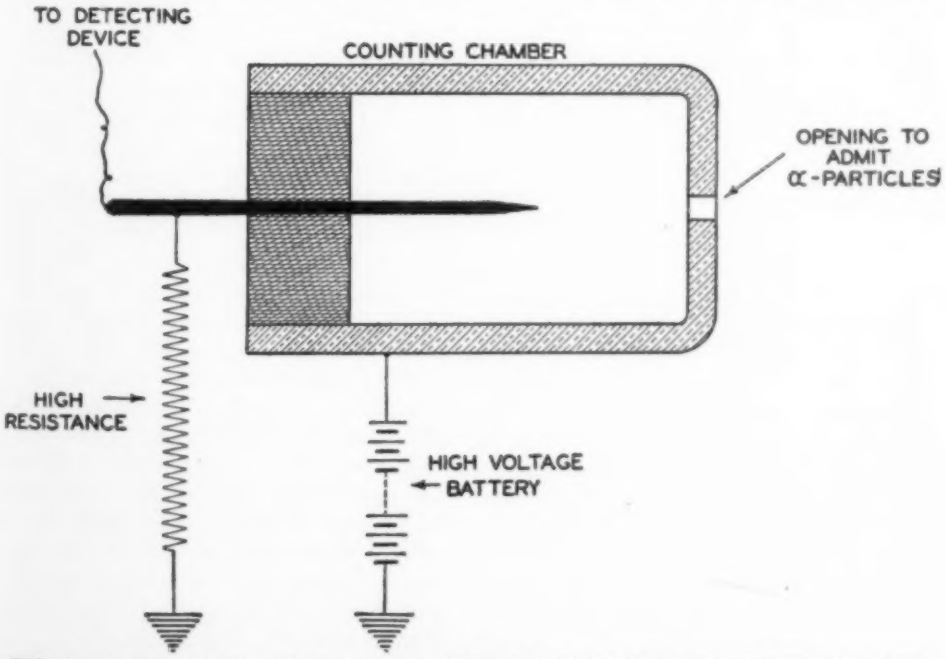


FIG. 1. A DIAGRAM SHOWING THE ESSENTIAL FEATURES OF THE GEIGER ION COUNTER.

counter returns to its original condition, if provided with a suitably treated point. The point is connected to ground through a high resistance which enables the charge acquired by the insulated system of the electrometer to leak off in time to receive another charge from the next α-particle to enter. It has been found very hard to explain why this ionization current does not continue, once started, so that it would be impossible to use the chamber for counting. All that has been known is that some special heat treatment is necessary to put iron or platinum points in a condition to act in the usual way. Heretofore, practically no other metals have been used successfully. There has been considerable discussion regarding what change is produced in the metal by repeatedly heating or fusing in a flame, the usual method of preparing a point. However, no satisfactory conclusions have been drawn, mainly because too little information has been available concerning the behavior of points under various conditions. In fact, so much confusion has existed that some investigators have postulated that the sensitive surface of the counter is not on the point but on the inner wall of the chamber. This is not the case, as we will see before we have finished with this discussion.

A few pertinent facts concerning the behavior of the counter, as reported by other investigators, should be summarized here for use later in the discussion. What might be termed the amplification factor of the counter is of considerable interest. Each α-particle of course is a single ion, being a doubly charged helium atom. By measuring the current which flows in the chamber for each α-particle counted, it is possible to determine how many ions are produced within the counter for each count and, therefore, how greatly the original stimulus has been magnified by the counter itself.

This has been done by various workers under slightly different conditions, but the average estimate is about 10^7 or 10^8 ions for each α-particle, so that one can appreciate at once what a powerful method is here offered. This also makes it evident that, by choosing a suitably high value of the high resistance, a "kick" of several volts may be communicated to the string electrometer so that for visual observations no further amplification is required. Another interesting fact that has been known is that very closely the same number of ions are produced in the counter during its operation for every particle that enters. To make clear what is meant by this statement it should be recalled that we really deal here with two types or stages of ionization of the gas in the chamber when a particle is counted. There is what may be termed the "primary" ionization, which is always produced by an α-particle when it traverses a gas. For example, when an α-particle passes through air at atmospheric pressure it produces about 3,000 ions per mm of path. However, we have seen that about ten thousand times as many ions are produced in the counter and this portion may be termed the secondary ionization or ionization by collision, which will be referred to later. Now it makes very little difference how far an α-particle penetrates into the counting chamber since the primary ionization contributes so little to the total effect. This primary ionization may be regarded as the trigger which sets the counter off. The fact that the ionization by collision part of the current remains approximately constant from one count to the next obviously means that the same quantity of gas is ionized each time and therefore that this ionization must occur in about the same portion of the gas. The full significance of this will appear when we come to a final discussion. A further proof that the primary ionization acts

in the capacity of a trigger is shown by observations which indicate that the lower limit to the number of such ions which must be produced by the α-particle to set the chamber off is relatively very small. This is shown by the fact that, if conditions are arranged so that the α-particles penetrate the chamber by a small fraction only of a millimeter so that only a hundred or so primary ions are produced, the α-particle is still counted.

In the work which will now be described, the writer started from a suggestion made by Geiger in a brief paper on this subject. It has always been difficult for those who have worked with this instrument to understand how the current pulse produced by the entrance of a particle is broken off so quickly. The interruption is almost instantaneous. In the article referred to, Dr. Geiger suggested that a layer of high electrical resistance on the surface of the point might explain this sudden interruption. As the current started it would cause a rise in potential of the point opposing that applied by the battery, thus finally reducing the effective voltage so low that the current would stop. He suggested that this layer might be due to the occlusion of gas within the metal by the heating which is necessary to prepare a point for use. To test the idea of high electrical resistance it seemed reasonable to try films of materials which were semi-insulating, coated over the point. Many such things were tried, such as various oils, lacquers, etc., as well as highly resistant metals, such as selenium. However, none of these was more than partially successful, and even these exceptions were undoubtedly due to the difficulty of coating a very sharp point completely by a thin film. However, during these trials an accidental observation was made which led to a new series of experiments.

By chance a steel needle was dipped in the phosphoric acid from an old drying bulb. This point worked beautifully and at first it was thought that the phosphate formed on the surface might be responsible for this. However, steel needles coated with the phosphate by other methods failed to work. While examining one of these points under a microscope, small bubbles, presumably of hydrogen, were noticed in the film of acid adhering to the needle and it seemed possible that the presence of this gas on the surface of the metal might account for the sensitive condition of the point. This idea was tested in the following ways. In the first place, another acid which attacks steel, such as dilute sulphuric, should produce the same result. This was tried and it was found to work.

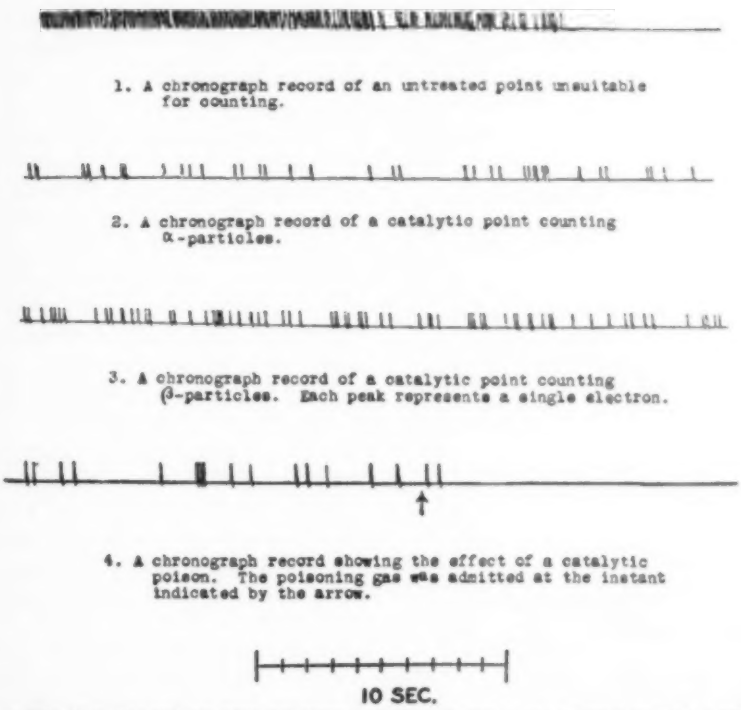
A further test of the hypothesis that a layer of gas is responsible for the action of the counter is provided by work with platinum points. If the gas formed by the acid is necessary, then dipping platinum points in acid should not help them. No effect was obtained by heating platinum points with acid. Furthermore, if the platinum point is used as an electrode in electrolysis, the gas thus deposited might be effective, which was found to be the case. Furthermore, it made no difference whether oxygen or hydrogen was deposited. Points prepared by any of these methods so far discussed were not very permanent or reliable, as might be expected. The next step seemed to be to find a better way of retaining the gas layer on the point. It was thought that this might be accomplished by using a catalytic substance. Accordingly it was decided to try some of the well-known metallic catalysts. Platinum black was the first to be tried. A platinum point was coated by electrolysis in a platinum solution. This point worked very well. Since only the platinum black surface should be necessary, steel points were coated with

platinum black merely by dipping them in the platinum solution. These also worked. These results gave great encouragement to the view that the catalytic condition of the metallic surface was necessary for a good point. However, it seemed desirable to subject this idea to more rigorous test. For example, further support might be obtained by working with a metal which can be put in the catalytic condition only by careful treatment. Copper is such a metal. It is significant that copper points have never previously been used in the Geiger counter with any success. Special treatment is needed to obtain catalytic copper; *i.e.*, slow reduction and oxidation at about 250° C. for several hours or days at a time. Copper points were placed in a glass tube which could be maintained constantly at about 250° C., and a stream, first of oxygen, then of hydrogen, was permitted to pass over them for twenty-four hours. At the end of five days these points were tried in the Geiger counter and all gave excellent results.

Another peculiarity of metallic catalysts is their susceptibility to "poisons." It is well known that the presence of such substances as mercury vapor, hydrogen sulphide and sulphur dioxide will under certain conditions ruin the activity of the ordinary metallic catalyst. This seems to result from a strong affinity between the catalysts and these substances and once they are adsorbed, they are not readily driven off, and so modify the surface that the catalyst no longer functions. It should, therefore, be interesting to admit these poisons to a counting chamber while in operation. A chamber was arranged with a side tube so that mercury vapor, hydrogen sulphide or sulphur dioxide might be admitted while counting. The result of this test was remarkably convincing. The instant the poison was admitted the counter at once ceased to function. All sensitive points which have been tried behave in this way. These results are regarded as an emphatic confirmation of catalytic theory of the sensitive point.

Any further doubts on this question are pretty well dispelled by observations with points of copper. As mentioned before copper points in air will not work. But catalytic copper in the oxidized state does. The reduced copper catalyst works in hydrogen but is poisoned by oxygen or water vapor. From adsorption measurements and other data it is well known that the reduced copper catalyst behaves peculiarly when exposed to carbon monoxide or ethylene. Both of these substances are adsorbed much more strongly than hydrogen, so strongly that they may be regarded as poisons for this catalyst. A counter with a reduced copper point was put in operation with a stream of hydrogen passing through it. The hydrogen was then cut off and carbon monoxide allowed to flow through. The counter at once ceased to function. Similar results were obtained with ethylene. To make this correlation still more convincing a freshly cleaned metallic copper point was tried in an atmosphere of carbon monoxide. From chemical data it is known that the carbon monoxide should not be so strongly adsorbed on an ordinary copper surface as to constitute a poison. In this case the copper point worked, although it ceased to work at once as soon as air was admitted. Thus it may be seen that, as far as trials have been made, the behavior of a point of any material under given conditions may be predicted from a knowledge of the catalytic behavior of the material under the same conditions and that the reverse should also be true.

In order to give the reader a little better idea regarding the behavior of the counter under the various conditions discussed, chronograph records are shown in Fig. 2. These records were obtained by connecting the counting



1. A chronograph record of an untreated point unsuitable for counting.

2. A chronograph record of a catalytic point counting α-particles.

3. A chronograph record of a catalytic point counting β-particles. Each peak represents a single electron.

4. A chronograph record showing the effect of a catalytic poison. The poisoning gas was admitted at the instant indicated by the arrow.

10 SEC.

FIG. 2. CHRONOGRAPH RECORDS OBTAINED WITH A VACUUM TUBE AMPLIFIER SHOWING THE OPERATION OF THE ION COUNTER UNDER SOME TYPICAL CONDITIONS.

chamber to a telegraph relay through a vacuum-tube amplifier. The relay then was used to actuate the chronograph. In the first line we have an example of an untreated, freshly sharpened metal point in air. This record was obtained by raising the voltage while particles were entering the chamber until the amplifier responded. The record represents a rapid series of brush discharges in the counter which are unchanged if the source of α-particles is removed. If the voltage is raised a little higher, a true arc strikes, melting the point. In the second line we have a record of a properly prepared point where each "kick" corresponds to the entry of an α-particle. The third line represents the same process for β-particles. In this case each kick represents the entrance of a single electron into the chamber. In the fourth line we have a record showing the result of admitting a catalytic poison into the counting chamber while in operation. The poisoning gas was admitted at the instant indicated by the arrow and as the record shows the point was at once ruined.

With this new information regarding the nature of the sensitive surface requisite for a satisfactory counter, it should be possible to construct a more accurate picture of the processes which take place in the counter than could be done previously. The writer has considered several explanations for the action of the sensitive gas layer and the general behavior of the counter which will now be presented. Before going into this phase of the question in detail, we must recall some features which exist in the counter as a result of its

peculiar arrangements and which play an important part in its action. Referring to Fig. 1 we note that the counter is an ionization chamber with very dissimilar electrodes. One is a point and the other is a very large surface. Under such conditions the electric potential between these two electrodes has a peculiar distribution. We may make this plain by showing in Fig. 3 the variation of the potential between

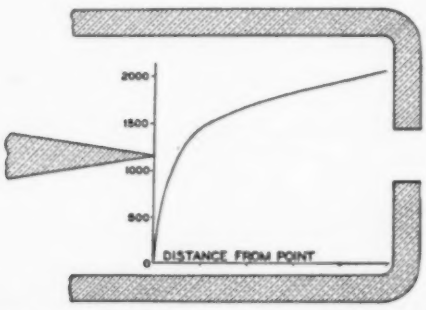


FIG. 3. A DIAGRAM SHOWING THE VARIATION IN POTENTIAL WITHIN THE GEIGER ION COUNTER.

two such electrodes. As may be seen from the curve plotted with axes placed in appropriate positions within the counter, the potential rises very rapidly indeed in the first few millimeters beyond the point and then after that only gradually. Hence an electron released from the point quickly picks up sufficient energy to ionize a gas atom, thus producing another electron in an intense field so that it also soon has energy to ionize and an ionization current is built up exponentially to a comparatively high value in this region where the potential gradient is high as shown by the curve. As soon as this disturbance proceeds to the region where the curve is more gentle in slope, little or no new ionization is produced, as the electric field is only strong enough here to carry ions already formed over to the chamber walls. The existence of a restricted region with intense electric field plays an important part in the operation of the counter and will be referred to again in more detailed discussion of its operation.

It is also important to remember that the counter works with a relatively high pressure of gas. By this we mean at atmospheric pressure or at some considerable fraction of it. The counter can not be relied on at all if the pressure is reduced below about five centimeters of mercury. With such high pressures of course the mean free path of the ions is very short. This means that very intense fields are necessary to give even the electrons sufficient energy to ionize at an impact since they can only acquire kinetic energy while moving freely. The positive ions, due to their relatively low mobility compared with the electrons, never can acquire kinetic energy enough to ionize by impact. When two thousand volts are applied to the counter the positive ions can acquire only a few hundredths of a volt kinetic energy on the average. Since the mean free path is of the order of 10^{-5} cm, if we consider the electric field at its most intense portion equal to 10^{3} volts per cm, the positive ion could only acquire about 10^{-2} volts for each free flight. Since it will share this energy equally on impact with the next atom the average energy acquired at any time by the positive ions is small. Of course a few will possess energy much higher than the average, but even this may be neglected when we realize that we require ions with energies of about fifteen volts or more to ionize by impact. This great difference between the electrons and the positive ions is very important in considering the nature of the processes which go on in the counter.

We are now prepared to consider the behavior of the counter in relation to the new facts concerning the catalytic nature of the sensitive surface on the point. In this discussion it must be borne in mind that this layer only func-

tions when the point is negative and it is then indispensable to the operation of the counter. With the point negative when a discharge occurs, electrons must come from the point and go to the chamber walls. It is well known that it is almost impossible to draw electrons from metals from which gases have been thoroughly removed. Consequently we must explain how the electrons are released from the gas layer we now know to be adsorbed on the point and how the catalytic property of rapid adsorption plays a part in the operation of the counter. The only change produced at the point when an α-particle enters the chamber is the arrival of a few positive ions which results from the primary ionization produced by the α-particle. Therefore these positive ions must be responsible for the release of electrons from the layer of adsorbed gas on the point. The diagram in Fig. 4 helps to

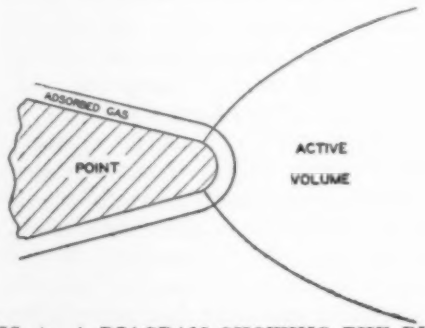


FIG. 4. A DIAGRAM SHOWING THE RELATION BETWEEN THE "ACTIVE VOLUME" AND THE CATALYTIC SURFACE ON THE POINT.

make clear the nature of the problem with which we are confronted. The experimental evidence here presented indicates that there is a layer of adsorbed gas necessary for the point to work which may be represented roughly, as shown in the figure. From the form of the electric field only ions formed within what has been labeled the "active volume" will be able to affect the point. Consequently only the small portion of gas near the point is involved in the process. We are now required to provide a mechanism which will provide for the release of electrons from the metal of the point out into the free gas of the counter by means of the adsorbed gas. We know that the positive ions do not have enough *kinetic* energy to ionize the atoms of the adsorbed gas. However, as soon as the positive ions arrive at the surface of this layer their *potential* energy resulting from their ionized condition is at once available for exciting or even ionizing the gas atoms. For experiments have been performed which show that an adsorbed gas has a lower ionization potential than a free gas. Therefore, the potential energy of these free gas atoms is greater than that necessary to ionize the adsorbed gas atom. Once a few electrons are thus released from the gas in the very intense field existing there, the remainder of the process seems comparatively simple. They at once acquire sufficient kinetic energy to ionize the gas in the chamber by impact. For each electron thus ionizing a new electron is produced, which also may immediately acquire ionizing energy. This process continues as the disturbance moves out toward the chamber walls until we come to the more gentle part of the curve in Fig. 3 when no new ionization is produced. During the initial part of the discharge the ionization current is building up exponentially and this process need continue but a short time to explain the observed amplification of the Geiger counter, *i.e.*, about 10^7. It should also be noted that we are now in a position to account for the sudden cessation of this ionization current, a fact that has hitherto been considered mysterious. This current can continue only as long as fresh electrons are supplied by the point. However, as soon as all the adsorbed gas atoms existing at the

tip of the point in the concentrated field are ionized, the supply of electrons is exhausted. Furthermore, the ionized atoms, plus the accumulation of similar ions from the gas, cause the point to rise in potential and momentarily reduce the intensity of the field in the very region where the electric field is most concentrated. Of course, in a very small fraction of a second, these atoms may recombine, drawing on the "free" electrons of the metal for this purpose, but when we realize that we only require them to stay ionized for the brief space of about 10^{-4} sec. to account for the interruption of the current it is easily seen that this is a possible explanation.

While working on the above explanation it occurred to the writer that if such ionization of the gas layer took place with subsequent recombination there might be a visible flash at the point for each count. This could be tested readily by connecting the counting chamber with a vacuum-tube amplifier, which in turn actuates a relay. For each α-particle entering the chamber the relay is heard to click. A slot was cut in the side of the chamber opposite the point and a microscope magnifying one hundred diameters was focussed on the end of the point. This arrangement was placed in a totally darkened room. After the eye was thoroughly adapted, requiring from twenty minutes to half an hour, a tiny flash was observable on the very tip of the point, appearing as a softly glowing cap. Four different observers were able to see these flashes and all agreed that they were entirely coincident with the clicks of the relay. This experiment was at first considered as strongly confirming the idea of ionization of the adsorbed gas layer. On second thought, however, it became apparent that this glow may be entirely due to positive ions from the gas in the chamber arriving at the point. Since the volume of the counter is kept swept free of electrons by the high voltage, these positive ions have no chance to recombine until they reach the point. At present there is no information available which might give preference to either view concerning the occurrence of this glow. However, since at least two explanations are possible for its appearance, it seemed well to consider further ways in which the electrons might be released from the adsorbed gas.

An explanation has been developed along these lines which would utilize the kinetic energy of the positive ions. We have seen that this is not sufficient to produce ionization, but the arrival of several hundred positive ions each with kinetic energy corresponding to a few hundredths of a volt will raise the temperature of the minute portion of adsorbed gas near the tip quite appreciably at the instant of impact. Davisson and Germer have shown in their recent experiments with reflection of electron beams from layers of adsorbed gas that these layers have a lattice pattern similar to the metal adsorbing them and that the gas layer at room temperature is in a *solid state*. They have also shown that this solid may be melted by raising the temperature a few hundred degrees. Now while the gas atoms are in the solid phase with a lattice structure like the metal, the free electrons of the metal should be able to diffuse readily into this gas lattice since the boundary between gas and solid is no longer clearly defined. If now the positive ions produced by the entry of the α-particle strike such a layer they may raise its temperature locally enough to evaporate a portion of the gas layer releasing the electrons in the intense electric field existing at the tip of the point. These immediately produce additional positive ions which, returning to the point, evaporate further gas atoms. This can continue until the adsorbed gas atoms are all removed from the restricted area near the tip of the point where the field is concentrated. When this occurs the dis-

turbance must cease in very much the same way as described above when discussing the release of electrons by ionization of the gas layer. Furthermore, since by this process the un-ionized adsorbed gas atoms are replaced by atoms from the chamber, these produced the same diminution in the electric field which was referred to it in the other explanation. This would then help in interrupting the current. Actually of course we know that such an effect exists in the counting chamber for, during the actual process of a count, the needle rapidly accumulates a charge, building up a considerable potential. For this reason it is necessary to connect the needle to ground through a high resistance so that this charge may leak off before the next α-particle enters the chamber; otherwise this later α-particle is not counted.

It is rather difficult to decide between these two possible explanations. As far as can now be seen either would account for the action of the chamber and there is some experimental evidence for each. Since the evaporation hypothesis requires less energy from the positive ions, perhaps it is to be favored unless more definite information supporting the former view can be produced. Furthermore, the evaporation idea makes more complete use of the catalytic nature of the point. On the ionization theory all that is required of the catalyst is to retain the gas on the point. In the second case, however, the gas layer is temporarily removed and the strong adsorptive properties of the catalyst are required to restore this layer in time to count the next particle. It is possible that ordinary metallic surfaces might hold sufficient gas to enable the ionization process to occur, but it would seem to require a particularly efficient surface to readsorb a gas layer rapidly enough to count particles which were entering the chamber within one hundredth or one thousandth of a second of each other as has been observed.

Thus far we have been able to account for the principal observations concerning the action of the chamber when the point is negative. The production of the ionization current has been explained by means of the release from the point of electrons which alone are capable of ionizing the gas. Since this is an exponential process the initial stimulus need be very small; that is, only a few electrons need be liberated so that the counter should count an α-particle as soon as it has entered. Furthermore, the disturbance should soon die out since the electrons will soon reach the chamber walls, after which no new ions will be produced in the chamber. Because the electrons from the point are responsible for the major part of the total ionization, and these electrons produce ions each time in the same region of the chamber for each α-particle counted, we expect the total ionization current for a given set of conditions to be approximately the same for each α-particle which is counted. In all these respects our explanation is consistent with the known behavior of the counter when the point is negative. It therefore seems reasonable to assume that some such process as outlined actually goes on in the layer of adsorbed gas when the point is in the sensitive condition to enable the electrons to escape.

We now turn our attention to the operation of the chamber when the point is positive. The counter has been used in this way only rarely and has not apparently given satisfactory results in all cases when thus tried. However, the writer has found, in agreement with one or two other observers, that the chamber works well this way at about the same voltage as when reversed. The further interesting observation has been made that the *nature of the surface* of the point is immaterial for the operation of

the counter when the point is positive. If a point of a given sharpness has the proper voltage applied it works regardless of the kind of metal or its treatment. This observation shows that adsorbed gas or catalysis can play no part in the action of the point when positive. This conclusion is further substantiated by attempts to "poison" points when operating at positive voltages. None of the catalytic poisons produced any effect. This is not very surprising when we realize that when the counter is used in this way we no longer need to release electrons from the point since they are already traveling toward it. We can now visualize the process of producing the ionization current for each α-particle entering, as follows: When the α-particle enters it produces as before a few pairs of ions. The positive ions go to the chamber walls. Since they have low mobility and are in the weakest part of the electric field when they arrive at the walls, it is scarcely conceivable that they can do more than be collected. The distribution of the electric field with the point negative is of course very similar to that when positive, as is shown by the diagram in Fig. 5. The region of rapid change of potential is still near the point and we may say that practically all the ionization current is produced in both cases in some such region as A and little or no new ions are produced by impact in the region B in each case. When the point is negative, electrons cease to ionize by impact after leaving the region of A since they are no longer accelerated enough between collisions to acquire the necessary kinetic energy. Turning to the case of the positive point we find that a few electrons are produced as part of the primary ionization by the α-particle on entering some part of the region B. These move toward the point and as soon as they reach the region A they begin to ionize by impact, since they are now in a strong enough field so that between each impact they acquire enough kinetic energy to ionize at the next impact. We now have a condition almost identical with that existing when the point is negative and a few electrons have been released from it. The ionization current builds up exponentially and the disturbance rushes rapidly to the point, the current being produced in the

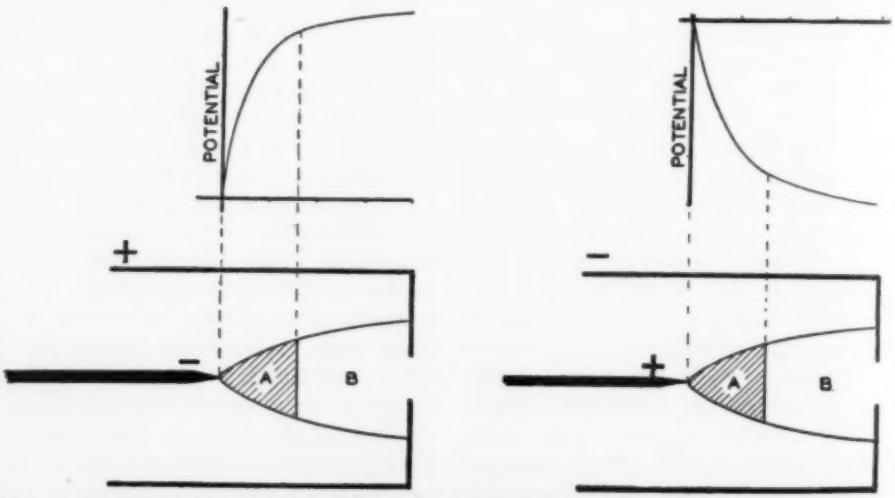


FIG. 5. A DIAGRAM COMPARING THE VARIATION OF POTENTIAL WITHIN THE ION COUNTER, WHEN THE POINT IS NEGATIVE, WITH THAT WHEN POINT IS POSITIVE.

same volume of the counter as when the point was negative. About the only difference between the two processes is that they travel in opposite directions. It is now easy to see also why this current at once ceases when the disturbance reaches the point. All the electrons are moving rapidly to the point while only the positive ions travel through the gas between this disturbance and the chamber walls. But these, as we have repeatedly mentioned, can not produce new ions by impact. Hence there is no means provided to produce a further supply of electrons in the rear of the disturbance as it moves to the point and the current dies out at once. The only way this current can be again started is by producing a few electrons in the B region of the counter, as, for example, by the entrance of another α-particle. This of course is just the condition which must obtain for the chamber to count successfully. Consequently it now seems to be clear why the counter behaves much the same on reversed potential, although in one case the nature of the surface of the point is so important and in the other it plays no part.

Additional work is, of course, required to further perfect the counter, making use of the information now available. Since there are certain advantages in working with the chamber when the point is negative it appears worth while to determine what conditions are really most favorable from the standpoint of sensitivity and permanence. For example, further study may show that the deterioration of negative points may be the result of slow catalytic poisoning from traces of SO_2 in the laboratory and that points may be made permanent by using only pure gases in the chamber. By such investigations one may hope to secure further improvement in the counter so that it may become more reliable. There is also the possibility that the counter may be used in studying catalytic substances or controlling the preparation of catalytic materials in industrial processes. Hence, this work may have a by-product of some practical value.

THE INTERPRETATION OF RESEARCH

By Dr. BENJAMIN T. BROOKS
NEW YORK, N. Y.

If Mr. Chesterton had ever been interested in scientific research he undoubtedly would have observed that the only enemies of scientific research are some of its friends. Research must usually be interpreted. The world at large, and particularly the business man interested in technical progress, and the youth, who may be groping about for a career, is entitled to know what is happening and what are the trends of research and its significance. The world is entitled to reliable information as to what is going on in our scientific laboratories. The average business man is convinced of the value of research, but the miracles of research, both real and imaginary, have been featured so much in the public press that, in the game of selling stocks and promoting fraudulent enterprises, mystery processes and chemical hocus-pocus play very much the same rôle in getting the public's money as mining stocks did in an earlier generation. Unfortunately, some scientific men are so imbued with the idea of "selling" research that they have contributed not a little to the success of those who are more frankly dishonest. The bad effects of lurid exaggeration and carelessness in the writings and public addresses of scientific men and others who attempt to interpret scientific work have become so evident that it is worth while to inquire whether the "selling" of research by the methods of modern high power salesmanship and advertising is not doing more harm than good.

Reference has been made to the evil results of casting science in the form of Hollywood scenarios. The following is the comment of Mr. Henry L. Doherty, given at the Williamstown Conference in 1926:

> The tendency of the day, however, is to get away from the thought that improvement is apt to come only from long work, conscientiously done and intelligently planned. We are flippantly told that research work aimed to secure minor improvements is not worth while and the man who is most readily accepted to the public as a scientist is the one with a mind best adapted to the occupation of a theatrical "press agent" who tells us that someone is about to "unlock the atom" and unloose energy without limit upon a world composed largely of old-fashioned scientists who have not learned and never will learn to work according to advanced ideas. It is apparent to every man properly trained along scientific lines that, regardless of what may or may not yet be discovered, such persons have no idea of what they are talking about, but the question is—did the originator of this, or other similar sayings, have even a definite dream in his mind, and if he did we would all like to know about it.
>
> It may be urged that it is no part of the activities of scientists either to reprimand or fight other people, but I hold it is the duty of every real scientist to reprimand and rebuke those who may make scientists appear impractical or ridiculous or who are an obstacle to the progress of science, and everybody who predicts some accomplishment to which he can not point to a proper reason therefor is an enemy to the progress of science and only by reprimand and rebuke can this damaging talk be stopped. I have been told at least a hundred times in the last four years that there is no reason to worry about the future of our oil supply, for science will surely find a substitute for petroleum. *I am sorry to say that some of the men who have said this have been classed by the world as scientists,* but most of them are without scientific knowledge of any sort and none of them have as yet been able to offer any evidence that they have the slightest knowledge which might justify such a statement.

The interpretation of scientific research is an exceedingly difficult matter. There are few men who can write with

the inspirational quality, beauty of diction and scientific soundness of Tyndall or Robert Kennedy Duncan, few such lecturers as Millikan and few busy investigators who will take the pains to put science into simple language filled with philosophic meaning, as Paul Heyl has done. But, apparently, there are people who believe that the "tabloid" newspapers should have "tabloid" science, phrased in the "peppy" sentences of Mr. Babbitt. Apparently, some believe that selling science is like selling religion and saving souls; probably the percentage of those who remain converted is the same in both cases. Some of the chromatic magazine covers, devoted to science and invention, suggest all the thrill and melodrama that Frank Merriwell and Nick Carter formerly supplied. Must morons be supplied with moron science? It would be more dignified and effective if we were to advertise in the subway with placards: "Patronize Your Neighborhood Research Chemist" and put up billboards in the country stating "Research Brings Business Health," or "Wealth from Atoms," embellished by a pink bathing beauty scrutinizing a test tube. Dignified slogans could be used, such as "Research Reaps Rich Rewards."

There can hardly be any question but that careless, bombastic or exaggerated interpretation of science does a great deal of harm. Not long ago the writer was discussing a public address recently delivered by an officer of one of our largest technical societies. The address in question was a romantic phantasy of what wonderful things were going to happen as a result of a certain line of research (if only some one would come forward and put up the money for said research). My friend said: "I recognize the applesauce you are talking about and its author, but what harm does it do? Nobody takes that sort of thing seriously. He is accustomed to dealing with young students who must be inspired by pretty fancies so that they will try things. Other people, in the full possession of their faculties and whose time is valuable, would never dream of trying such things." Aside from the question as to whether such romancing is good pedagogy, it is not intended as fiction and is therefore *not honest*. With the exception of a few fundamentalists the world has come to believe that the essence of the search for scientific truth is honesty, and any one who has won recognition as an investigator comes before the public forum with this badge of the guild stamped upon him. What is going to be the feeling of the business man who has sunk money in ill-considered research, if he is told that public addresses should not be taken seriously, that this is just one way of selling research, just the big noise outside the tent? What is going to be the feeling of the student, whose time is taken during the arduous years of his technical training, when he discovers that his research director was only using him as a pawn in the effort to achieve a little sensational publicity, that the research on which his time was used was scientifically unsound or foredoomed to failure as to industrial usefulness by economic facts.

It is true that a great deal of money has been made and is being made by scientific research. Research is scientific exploration. Research is the one kind of speculation which is absolutely essential to technical progress. But there is another side to the picture. A great deal of money is lost in ill-advised unsound research and in research conducted by incompetent investigators. Perhaps it is a kind of heresy to mention these facts. It is true that it is difficult to judge the unknown. It is difficult or impossible to estimate the chances of success with any accuracy. But an honest attempt can be made to make an "estimate of the situation," as the student of military opera-

tions phrases it, first with respect to the economic limitations and second as to the scientific soundness of the project. The story is told of Professor Adolph von Baeyer, the grand old man of organic chemistry, that a research student suggested that he be allowed to take up the synthesis of quinine so that it could be manufactured instead of extracting it from Peruvian or Ceylon cinchona. A good idea, but the old master is said to have replied: "Young man, you will not live long enough." Quinine undoubtedly will be synthesized in the course of the march of chemical research, and perhaps manufactured cheaper than the natural product. But Baeyer, the greatest organic chemist of his time, did not consider it a good bet.

There has been considerable discussion among scientific men in recent years regarding the question of professional ethics of expert witnesses called to testify in cases before the courts. The general result of this discussion has disclosed the fact that, save for a very few flagrant cases, the standard of professional conduct has been above reproach. The exceptions are very difficult to deal with except by general condemnation by the scientific fraternity. The "selling" of research by gross exaggeration is no less reprehensible and has more far-reaching evil effects than perjury by an expert witness. The only way to stop the selling of scientific research by public utterances resembling the tooting of a steam calliope is by the vigorous disapproval of scientific men themselves. This is not so easy or as certain of results as it sounds. University trustees have been known to promote the professor who rushes to the public with visions of driving vessels across the ocean by releasing the electronic energy of a thimble full of matter. Just what kind of matter or just how the energy is to be released and applied are, of course, details that are omitted in the rush for publication. So long as trustees desire this type of professor one can not be surprised if there are a few professors willing to supply the demand. There has been a genuine desire shown by the best of our public press to keep the scientific quack and charlatan out of its columns, but every newspaper loves a sensation and only the best of them hope that the sensations which they print are all true. The American Chemical Society has been holding a series of special summer meetings given over to round-table discussion of research subjects, an altogether pleasant and worth-while series of meetings. But there is always at least one jack-in-the-box, who must jump up, if only to say something which the late afternoon press will feature with the baseball scores. At the recent Evanston meeting armies were anesthetized by chloroform, chemical warfare gases were destroyed by peroxides, and thousands of tons of synthetic rubber were made from the waste gases of petroleum refineries, all in one afternoon. Nobody wishes to suppress such discussions, but since newspaper men look very much like other people, externally, they invariably find a way in, and a good reporter can smell a sensation as far away as a camel can smell water. There is always a great deal of difficulty with censors; they are as popular as baseball umpires. The only practical remedy is for scientific men to be more careful of their *public* utterances.

Another reason for some of the vigorous optimism of some of our popular science lecturers and writers is the rather large amount of money which is spent upon research. Competent research men certainly are not paid too well, but they are generally much better paid than many other classes. The director of one of our best known and most successful industrial research lab-

oratories recently told the writer that in his experience only about twenty out of every one hundred Ph.D. men given temporary employment with his company were sufficiently competent to be considered for longer employment. What happens to the researches that the incompetent 80 per cent. undertake for other companies? How many of them continue to take advantage of the widespread and liberal financial support of scientific research, only to make a living, until their employers become disgusted or lose their money? Of course, all such matters adjust themselves in time, but often with a good deal of disappointment all around. Ill-considered, unsound research propaganda leads to the employment of many incompetent persons on unsound research projects; the employer loses not only his money but his patience and his faith in scientific research as an aid to his business.

It may be worth while to illustrate the different methods of soliciting financial support of research by considering the case of synthetic rubber. It is not necessary to go into technical details. Let us remember that at the International Congress of Applied Chemistry held in New York in 1912, Dr. Duisberg, one of the directors of the famous Radische Co., exhibited an automobile tire made of synthetic rubber. The conversion of certain very reactive hydrocarbons, such as isoprene, into rubber-like material has been an accomplished fact of scientific interest for about twenty years. The rubber-like material produced in the laboratory has never been equal to natural rubber in quality, and rubber chemists who have studied the matter intensively for many years can give many reasons for this difference. But assuming that research and skill will in time bridge this gap, the real problem consists in finding a source of the raw material, isoprene, which will be substantially cheaper than the cost of producing natural rubber on the Indo-Malay plantations, where it can be produced for about twenty-five cents per pound. If a satisfactory synthetic rubber could be manufactured at a cost only a little greater than this figure we might then have a situation like the case of natural camphor and the synthetic product, made from spirits of turpentine; the synthetic product serves as a check on the price at which natural camphor, a monopolized article, may be sold. No one questions the importance of rubber in our present industrial scheme of things. Our American requirement is something like seventy-five to eighty million pounds per month.

Let us suppose that both A and B are optimistic research chemists and that both need money equally badly. A represents the matter to a business client something as follows: "There is nothing really difficult about the commercial synthesis of rubber. In fact I have made a specimen recently from petroleum, which you may examine. All I have to do is to improve the yields somewhat and it will be a commercial proposition. A billion pounds of synthetic rubber per year will be an enormous business, which will make an equally enormous fortune for somebody, and the manufacturer who develops this business will earn the undying gratitude of the nation for making us independent of the natural supply. All this problem needs is a little intelligent, optimistic research. Rubber is a hydrocarbon; petroleum is a mixture of hydrocarbons and all we have to do is to convert the one into the other by processes which are to a large degree already known and understood, etc., etc."

B states the case about as follows: "This is an attractive problem from a scientific standpoint. However, I would suggest that we make a preliminary investigation along several lines. We should find out what the situation is

with respect to plantation rubber, whether improvements have been made or more extensive areas planted, which may materially lower the cost of producing natural rubber. It will also be of interest to find out whether manufacturers of rubber articles can utilize a substantial tonnage of synthetic rubber of the quality which the researches of the last twenty years have shown can be produced, provided we solve the problem of a satisfactory raw material. What special markets exist for inferior rubbers, and would it be possible to improve upon the natural product? Would you be willing to meet the budget of such a research for a period of at least five years? It is my opinion that the problem is a difficult one and several very able men should be employed. The annual expense would be about _____ thousands of dollars. Petroleum has frequently been suggested as a suitable raw material. Prior investigators have of course not overlooked this possibility and beginning with Engler and Staudinger in 1910 the results to date have been about so and so. It is possible that many so-called by-products may have to be utilized, if we use petroleum, and this may make it possible for you to get your money back even if we do not succeed in making synthetic rubber, itself, commercially. We shall certainly discover many things of scientific value and interest in the course of our work, which will make it worth our while, as scientists, but we can not guarantee you financial returns with the same degree of certainty. If, having given you the scientific aspect of the problem as best I can, and after studying its economic aspects, you believe, as I do, that it is a good speculation, then 'Here is how.' "

The case for theoretical research without any specific industrial objective is quite another matter. The director of a well-known industrial research laboratory told the writer recently that every purely theoretical discovery made in their laboratories had found an industrial application within two years of the discovery. But selling theoretical research is rather too difficult for the popular writer and is seldom attempted. Professor Pupin has told of the great effect that Tyndall's lectures in this country in the seventies had upon the popular support of theoretical research. Even this great cause suffers at times from the zealous exaggerator. He would balance a great industry upon the point of a single theoretical discovery. But, as Robert Kennedy Duncan phrased it, many great problems are solved by the organized attack of a veritable army and the methods of advance are comparable to the slow fighting and advance of a siege. The cancer problem is such a one, and the final solution, when it comes, will rest upon an enormous foundation of painstaking research by a host of workers.

Many of those who undertake to interpret research or seek to dazzle with their prophecy are probably the counterpart in science of those who, in the field of art, seek to gain fame by painting cubist pictures, writing free verse or dissonant music. Unwilling or unable to learn the technique of their art or of science, they leap to the stage and pose as true prophets of the future.

Undoubtedly the greatest good that can result from the proper interpretation of science is the inspiration of youth with the ideals of science and zeal for research. One of our most gifted interpreters of research recently gave an address on "Carbon," which dealt first with soot, carbon black, coal, then with the diamond and finally with the daring objectives of modern organic chemistry. He explained to me that he believed all elementary students should be occasionally led to the mountain top, to a high point of vision so that they might see all the beauty and supreme importance of

scientific endeavor and he stated that at the same time it should be explained to them that only by a great deal of hard work could they fit themselves to participate in the glory of the great achievements. One of the finest and most daring examples of inspirational teaching that has come to the writer's notice is being made at one of our state universities of the Middle West;[1] the students of general chemistry are given a series of ten lectures on the nature of matter, including the essential facts so far discovered of the structure of atoms, something of stellar evolution and the explanation of stars of abnormal densities, atomic disintegration, the space lattice of crystals, and the like. Five special lecturers, including a professor of physical chemistry, a professor of astronomy and a professor of mineralogy, put their best effort into these lectures. Such interpretation of science is an art, and, like all great art, it is extremely hard work. If there should be any question as to whether such teaching is effective, a recent statement of Dr. W. R. Whitney, director of research of the General Electric Company, gives the answer. Dr. Whitney stated that in over thirty years he had "never known a good, able man to come from a poor teacher."

In conclusion, it may be worth while to consider the general reader a little. The cultural value of scientific education has never been appreciated as it is at the present time. Since the radio is in nearly every home, who has not heard of electrons? Who has not heard of vitamins, insulin and perhaps even the cosmic ray? There is a large proportion of the reading public that is seeking information regarding scientific subjects, and they are entitled to serious consideration. A mathematical physicist once told the writer that there were probably less than a dozen men in America who could read the mathematical papers of James Clerk Maxwell and understand them, and the same probably applies to the publications of the famous physical chemist, Willard Gibbs. While these examples are somewhat extreme, there is no question of the need for adequate translation of science, from the language of mathematics, physics and chemistry into English. Interpretation means more than making the facts intelligible; we wish to know what it all *means*, what scientific discovery is doing to our philosophy and our mental life, as well as the world of fact and our prospect of health and happiness. Professor Michael Pupin's "The New Reformation" and Dr. Arthur S. Eddington's "Stars and Atoms" may not be among the best sellers and may not have placed these authors on a popular lecture circuit, but their interpretation of science is in the spirit of the highest scientific ideals.

[1] Ohio State University.

HUMANIZING GEOLOGY

By Dr. CHAS. N. GOULD

OKLAHOMA GEOLOGICAL SURVEY

In Oklahoma we are now placing the guide-book by the side of the road.

The Lions Club of the thriving little city of Ardmore, aided by the Ardmore Geological Society, has placed by the side of the new highway north of the city a dozen signboards descriptive of the various geological formations exposed on the surface in the Arbuckle Mountains.

The Arbuckle Mountains[1] of southern Oklahoma are an object lesson in geology. Those who know tell us that in no single area of similar size in the United States are there so many geological features as in this region. With the exception of glacial phenomena and volcanic phenomena, almost the entire gamut of geology may be observed in these mountains.

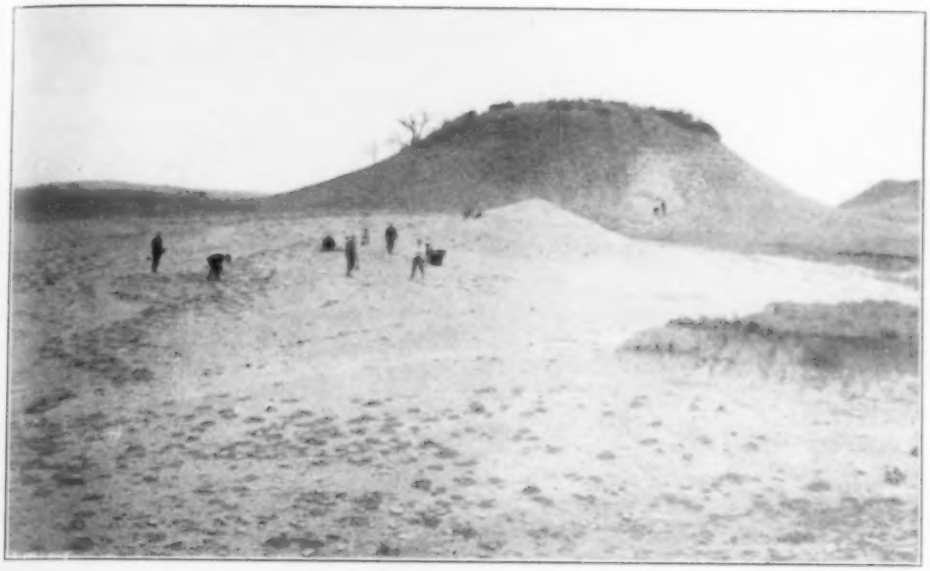
To go a long way back toward the beginnings of geologic history, in far-off Cambrian times, the area where the Arbuckles are now located was a shallow sea. The first rocks deposited in this sea and the oldest stratified rocks in Oklahoma were sandstones and arkoses washed in from some nearby land. This is the Reagan sandstone. The sea gradually deepened and for long eons limestone was deposited, one layer after another, until a total thickness of about eight thousand feet of limestone had been formed. This is the Arbuckle limestone, a great series of massive ledges, one of the thickest limestone formations found anywhere in America.

[1] The Arbuckle Mountains were named from Fort Arbuckle, which was located near the west end of the mountains. The fort was named from General Matthew Arbuckle of the United States Army.

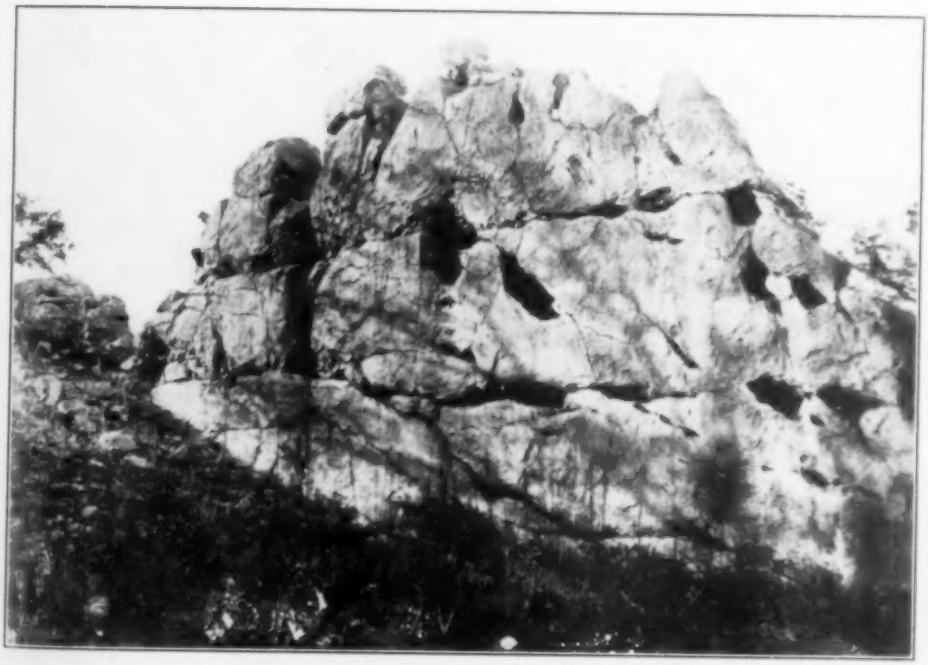
After the deposition of this massive limestone, the land again rose and a formation fifteen hundred feet thick was deposited. This is the Simpson formation, composed of sandstones, shales and thin limestones. At several places in Oklahoma the sands of the Simpson formation are quarried for glass sand, while in other parts of Oklahoma this sand is called the "Wilcox" oil sand. In the Seminole oil field, during the last year, this sand, which is encountered in wells more than four thousand feet beneath the surface, has produced as much as five hundred thousand barrels of oil per day. Other members of the Simpson formation are Burgen sandstone and Tyner shale.

Lying above the Simpson is the Viola limestone, eight hundred feet thick; then, in ascending order, are the formations known as the Chimneyhill limestone, Henryhouse shale, Haragan marl, Bois d'Arc limestone, Woodford chert and Sycamore limestone. The total combined thickness of the various formations is about twelve thousand feet.

All these formations were deposited during lower Paleozoic time; the Reagan is Cambrian in age; the Arbuckle is Ozarkian and Canadian; the Simpson and Viola are Ordovician; the Sylvan, Chimneyhill and Henryhouse are Silurian; the Haragan and Bois d'Arc are Devonian; while the Woodford and Sycamore are Mississippian in age. There are in the series many erosional unconformities, representing times during which the area doubtless stood above the ocean, when erosion cut away exist-



"WHITE MOUND" IN THE ARBUCKLE MOUNTAINS
FROM WHICH MYRIADS OF FOSSILS HAVE BEEN OBTAINED.



A LEDGE OF WEATHERED LIMESTONE
STANDING ON EDGE IN THE ARBUCKLE MOUNTAINS.

TURNER FALLS

NOTE THE CLIFFS OF TRAPROCK ON BOTH SIDES OF THE FALLS. VIEW TAKEN IN LATE SUMMER TIME WHEN AMOUNT OF WATER WAS LOW.

FOLDED AND TWISTED ROCKS

ing land masses, and no deposits were laid down.

At the close of the period of deposition just described, which extended over many million years, there came a period of orogeny, or mountain making. Great stresses and strains were set up, which compressed or squeezed together the rocks. The entire area now occupied by the Arbuckle Mountains was uplifted like a gigantic blister sixty miles in length, and the rocks which were originally deposited as level-lying sediments in the various Paleozoic seas, were uplifted and tilted so that near the periphery of the range the various ledges now stand on edge, often at an angle of 90 degrees from their original position.

After the elevation of the mountains, erosion at once began to cut down the rocks, and carry the débris into the ocean. This process is still in operation.

Geologists who have studied the matter are not entirely agreed as to whether the elevation of the Arbuckle Mountains took place in a comparatively short period of time, so that the mountains once stood more than two miles above their present level, or whether the uplift was accomplished so slowly that erosion about kept pace with the elevation of the rocks. Whichever method obtained, the fact remains that at the present time the mountains as a whole have been planed down until the general surface consists of a comparatively level plateau, lying at an elevation of about four hundred feet above the level of the surrounding country.

Streams taking their rise in this plateau and flowing toward the north have eroded canyons, and at the place where these streams have cut their way across the upturned ledges of the hard limestones one finds many beautiful waterfalls.

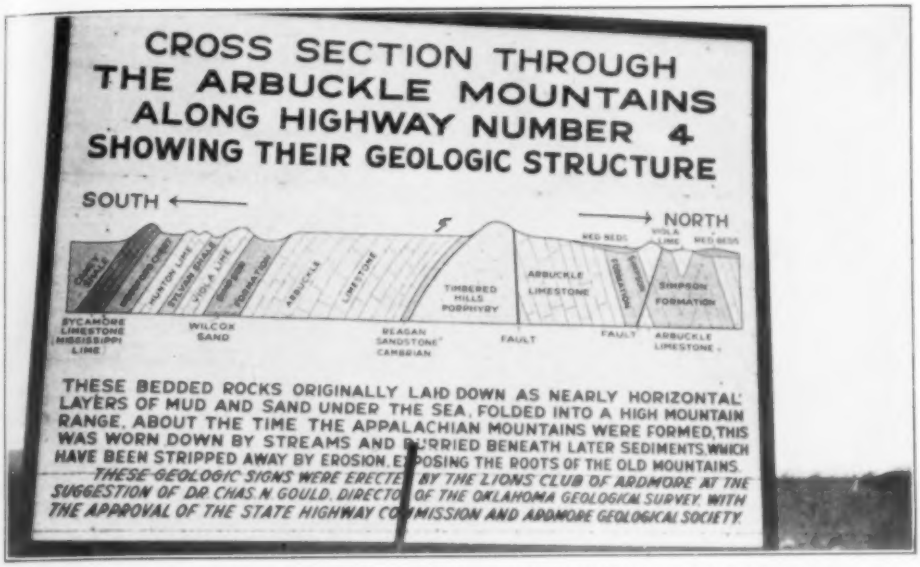
GEOLOGISTS AT WORK

IN THE FIELD IN THE ARBUCKLE MOUNTAINS

United States Highway No. 77 crosses the Arbuckle Mountains north of Ardmore. This is one of the main arteries of travel north and south across the states of the Great Plains. The days of the covered wagon and the deep-rutted roads are over, and to-day hard-surfaced highways checkerboard Oklahoma. The

COLLECTING FOSSILS

FROM PENNSYLVANIAN, TWO MILES NORTH OF ARDMORE, JUNE 27, 1927. LEFT TO RIGHT: DRS. C. E. DECKER, C. W. TOMLINSON, H. D. MISER, C. L. COOPER.


CROSS SECTION THROUGH
THE ARBUCKLE MOUNTAINS
ALONG HIGHWAY NUMBER 4
SHOWING THEIR GEOLOGIC STRUCTURE
SOUTH
NORTH
SYCAMORE LIMESTONE MISSISSIPPI LIME
WILCOX SAND
REAGAN SANDSTONE CAMBRIAN
TIMBERED HILLS PORPHYRY
FAULT
ARBUCKLE LIMESTONE
FAULT
ARBUCKLE LIMESTONE
SIMPSON FORMATION
THESE BEDDED ROCKS ORIGINALLY LAID DOWN AS NEARLY HORIZONTAL LAYERS OF MUD AND SAND UNDER THE SEA, FOLDED INTO A HIGH MOUNTAIN RANGE. ABOUT THE TIME THE APPALACHIAN MOUNTAINS WERE FORMED, THIS WAS WORN DOWN BY STREAMS AND BURRIED BENEATH LATER SEDIMENTS WHICH HAVE BEEN STRIPPED AWAY BY EROSION, EXPOSING THE ROOTS OF THE OLD MOUNTAINS.
THESE GEOLOGIC SIGNS WERE ERECTED BY THE LIONS CLUB OF ARDMORE AT THE SUGGESTION OF DR. CHAS. N. GOULD, DIRECTOR OF THE OKLAHOMA GEOLOGICAL SURVEY, WITH THE APPROVAL OF THE STATE HIGHWAY COMMISSION AND ARDMORE GEOLOGICAL SOCIETY.

DIAGRAMMATIC CROSS-SECTION OF THE ARBUCKLE MOUNTAINS.

Arbuckle Mountains, extending east and west, interposed their bulk across the main line of communication from north to south. The Santa Fé railroad detoured several miles to the east and found a water gap at the place where the Washita River had sawed its way downward through the heavy limestones. But the highway, seeking a shorter course, climbs the Arbuckle Mountains and runs for six miles along their crest. Thousands of cars daily travel this highway.

It is along this highway where the grade winds down the south side of the Arbuckle Mountains that the guide-book signs have been placed, calling attention to the various formations crossed by the highway. And surely no better place could have been found. In grading the road across the mountains, it was found necessary to blast away many of the ledges, laying bare exposures of rock not previously seen.

In Oklahoma, geology is no longer a strange thing. The people of the state do not look upon geologists as either pedants, freaks or soothsayers. Geology has to-day taken its place among the professions, the same as engineering, law or medicine. In Oklahoma nearly one thousand men follow the profession of geology.

At the State University at Norman, ninety miles north of the Arbuckle Mountains, a geological faculty of fifteen men instructs over thirteen hundred young people. Practically every large city in the state has its geological society. It is largely due to the labors and investigations of these men that Oklahoma to-day ranks second among the states of the Union in new mineral wealth per year. It is the geologist who has been largely responsible for the discovery of the three hundred oil fields of the state, that last year produced petroleum products valued at approximately $500,000,000.

And it is in the Arbuckle Mountains that many of these geologists first received their early training. For many years it has been the custom to conduct field parties from the State University

AN OUTCROP OF THE VIOLA LIMESTONE
IN THE ARBUCKLE MOUNTAINS.

and from other schools in Oklahoma and adjoining states into the Arbuckle Mountains. It has been estimated that during the past two decades five thousand young people have studied formations and collected fossils in these mountains.

So that it was the logical thing for the Geological Society of Ardmore to stand sponsor for the idea of labeling the rock formations of the mountains along the newly constructed highway near their city.

AN OUTCROP OF SIMPSON FORMATION

AN OUTCROP OF THE TYNER SHALE
PART OF THE SIMPSON FORMATION.

The moving spirits in the matter were the writer and Dr. C. W. Tomlinson, a graduate of the University of Wisconsin and the University of Chicago, who is practicing his profession as geologist for one of the petroleum companies operating in Oklahoma. He is also a member of the Lions Club of Ardmore. Some two years ago Dr. Tomlinson began to agitate the matter, and succeeded in interesting the members of the Lions Club in financing the undertaking.

Soon after the completion of the highway the signs were erected by the roadside. Eleven of these signs, each describing a single formation, are four by five feet in size, substantially placed, and should last for many years. The largest sign, located on the highest point along the highway, is eight by twelve feet in size and contains a diagrammatic cross-section of the Arbuckle Mountains.

In true western style every one cooperated. While Dr. Tomlinson led off and the Ardmore Lions Club stood sponsor for the finances, other agencies contributed in various ways. The Chamber of Commerce and the Ardmore Geological Society gave assistance. The State Highway Commission varied an established rule and gave permission for the erection of the signs on the right-of-way.

And the people use the signs. It is no uncommon thing to see half a dozen cars lined up by the roadside and the tourists studying the cross-section and reading the description. In distant states one hears remarks anent the geological signs in the Arbuckle Mountains at Ardmore.

The effect is good. The guide-book is by the roadside. He who runs may read, and as he reads the descriptions on the signs and studies the rocks to which the signs refer, he gets an idea of what it is all about.

Thus, in Oklahoma, we are humanizing geology.

AMERICA'S CORN CROP AND THE CORN BORER

By Dr. W. H. LARRIMER

BUREAU OF ENTOMOLOGY, U. S. DEPARTMENT OF AGRICULTURE

AMONG notorious insects which have received the wide-eyed attention of the public probably the European corn borer heads the list. Scientists and others who had been in touch with the corn borer situation realized that farmers were confronted by a dangerous insect, indeed one that might threaten the $2,000,000,000 corn crop, but to the majority it took the ruin of the Canadian fields to fully arouse them to the destructive possibilities of the corn borer. Of this destruction in Canada, Professor Lawson Caesar, provincial entomologist, Ontario, Canada, writes:[1]

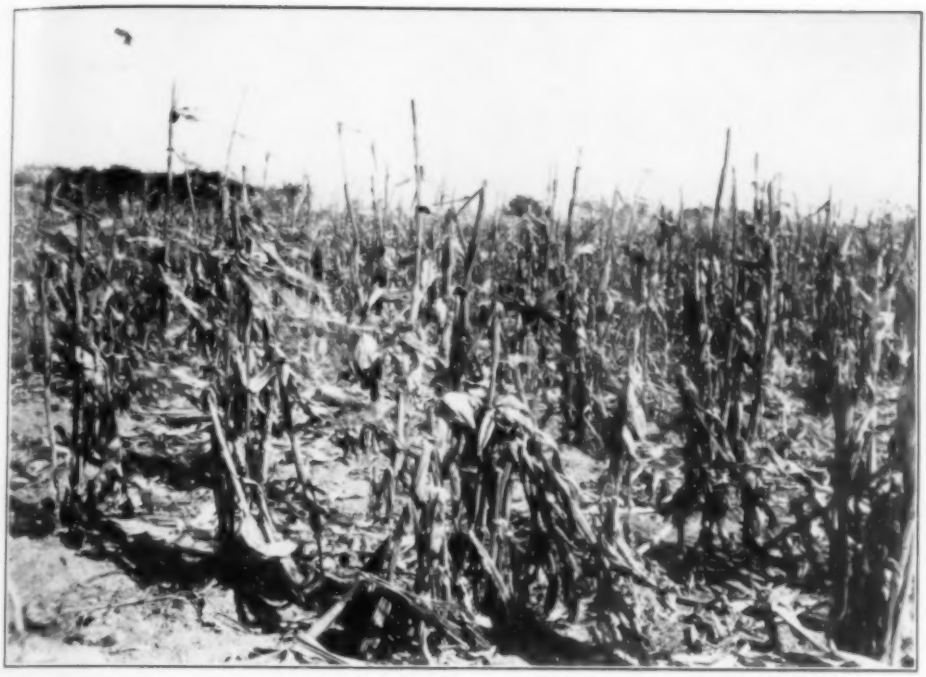
> A severely infested corn field such as was common in Essex and Kent in 1925 and 1926 before the Corn Borer Act came into force is a sickening sight. Such fields often have from twenty to fifty borers on an average to every plant. The result is that almost every tassel is off; nearly all the leaves have fallen or are hanging down close to the stalk; the stalks in many cases have fallen down and formed a tangled mass, or, if still standing, are bare and brown. The result is that the whole field looks somewhat like a spruce forest after a fire has run over it. Any one who has seen such a field will not doubt the power of the borer, if not controlled, to destroy the corn industry.

Such a failure of the corn crop over 1,200 square miles in Ontario aroused immediate action in the United States and, in the spring of 1927, Congress provided for the most colossal plant protection movement ever launched, the $10,000,000 corn borer clean-up campaign which was undertaken and successfully completed.

[1] Lawson Caesar, "The European Corn Borer," Bull. No. 334, Ontario Dept. of Agr., Ontario Agr. College.

There were two important questions for which answers were sought in the large scale clean-up campaign. First, there had been a more or less friendly disagreement with the opinion of the entomologists who doubted that the further spread of the corn borer could be prevented. Second, the entomologists and others were alike interested to know whether the corn borer could be controlled. The "Clean-up Campaign" answered these two questions; first, the borer will continue to spread to new territory in spite of everything that can be done; second, the numbers can be kept low enough to prevent serious commercial damage by the clean-up methods so well advertised by the campaign. As the corn borer advances into the great corn belt, the problem therefore becomes one of controlling it by a thorough and concerted clean-up of all the previous year's corn remnants before June 1, and prevention of long distance spread by maintaining a strict quarantine of the infested area.

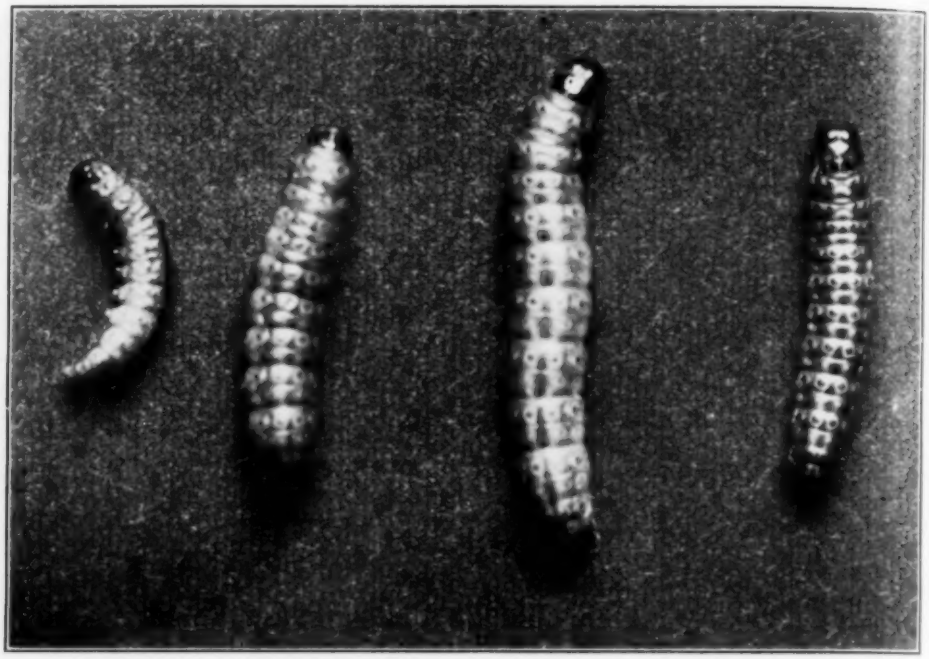
The corn borer was introduced into this country probably about 1910 in shipments of broom corn from southern Europe. As this was before the Plant Quarantine Act of August 20, 1912, the borer had a good chance to get in and develop undisturbed. The insect was first discovered here in 1917 near Boston, when it was estimated to infest about one hundred square miles of territory. Stewart C. Vinal, of the Massachusetts Agricultural Experiment Station, who discovered the pest, immediately began to study its economic importance and possible methods of



HEAVILY INFESTED CORN FIELD IN ONTARIO (OCTOBER, 1927)

control. In 1918 the investigation was carried on in cooperation with the U. S. Bureau of Entomology and in 1919 the Federal entomologists took over the work. As the borer steadily advanced and the gravity of the situation became more apparent, the organization was expanded and the problem attacked from all possible angles. At present the research problems are being studied at six Federal laboratories, scattered throughout the infested area of the United States, and one laboratory maintained by the United States in central Europe to study the insect in its native habitat. The search for effective parasites is also being carried on by Federal entomologists in Europe, with the main laboratory at Hyères (Var), France, and in the Orient, with headquarters in Japan. Surveys are conducted each year to determine the spread and the intensity of infestation, while a strict quarantine on infested products is enforced throughout the corn borer area. Many of the infested states have excellent research organizations at work on the corn borer problems and several of the threatened corn belt states are studying the pest in advance of its inevitable entry into their territory. State regulatory forces are doing everything practical to meet the difficult situation presented by the presence of a new pest of such potentiality.

The region now infested with corn borers includes all or parts of thirteen states (map). The western area most important in the spread towards the corn belt includes the southern and eastern sections of Michigan, the northeastern corner of Indiana and the central and northern portions of Ohio. The borer is known to have traveled to within thirty miles of Lake Michigan and probably the scouting now being carried on will reveal the thirty miles bridged and that a zone of infestation has been added around the edge of the present infested area.



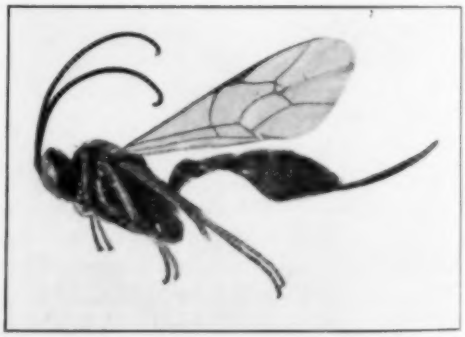
THE CATERPILLAR STAGE OF THE EUROPEAN CORN BORER

IT IS IN THIS STAGE THAT THE BORER DOES THE DAMAGE AND ALSO THE STAGE IN WHICH IT CAN BE CONTROLLED BY CLEAN-UP OPERATIONS.

Most of this area, however, is still very lightly attacked, having less than 1 per cent. of the stalks infested; that is, less than one stalk in a hundred contains a borer. The only place where the population has built up sufficiently to cause commercial damage is in a very narrow strip along Lake Erie. It is estimated that between five and ten borers per stalk are required to cause noticeable commercial damage.

The corn borer is a whitish caterpillar with a brownish or often a pinkish tinge. It is about one inch long when full grown, and has a dark brown head and many small brown spots on its body. The young borers, even when very small resemble closely those that are full grown, but are often when about one half inch or a little more in length a good deal darker in color

The caterpillar winters inside pieces of stalk, stubble or ears of corn and sometimes in weeds and other plant material growing close to corn. Its presence can be detected by small entrance holes on the surface. These holes are usually plugged with the castings of the borers. When the stalks, stubble or



ONE OF THE IMPORTED PARASITES OF THE EUROPEAN CORN BORER

A FEMALE OF *Eulimneria crassifemur*. ABOUT FIVE TIMES NATURAL SIZE.

ears are split open, the borers are usually found within.

As soon as warm weather begins in April or May, the borers resume activity although no real feeding takes place. The borer cuts a small circular opening from its tunnel to the surface of the plant in order to provide an exit for the future moth. This opening is usually closed with a thin partition of silk. The borer then retreats into its tunnel to a point near the last feeding or shelter place, where it usually spins a thin cocoon in which it changes to the pupal stage. The pupa is shuttle shaped, and varies in color from light brown to dark brown, and in length from one half to five eighths of an inch. After a period of from about ten to fourteen days the skin of the pupa splits and the moth comes forth. In the Great Lakes area the moth is present in the fields during late June, throughout July, and during early August, under average weather conditions.

The moth measures about an inch from tip to tip of the wings and varies in color from pale yellow to light brown. The moths of the corn borer resemble so closely several other kinds of moths that it is almost impossible for the average person to distinguish them. They are strong fliers, experiments having shown them to fly at least twenty miles, and it is very probable that they do fly greater distances. Large bodies of water do not check their flight, for they have been seen to alight on the surface of the water and again take flight. It is probable that moths have flown across Lake Erie in this way. This flight of the moths (like the blowing of the wind, that can not be prevented) results in a natural spread into new territory for distances of between twenty and thirty miles each year.

Soon after emergence the moths mate and begin to lay eggs, each female moth laying an average of 400 eggs. They remain quiet during the day, hiding in patches of weeds and grass or underneath the leaves of other plants. During the early evening and early morning they fly from plant to plant, laying their eggs usually on the under-side of corn leaves.

The eggs hatch in from four to nine days and the little caterpillars soon eat their way into the corn plant where they spend their life, tunneling up and down the stalks into the ears, and unobserved eating out the life of the corn plant. It is at this time that the damage is done.

As is the case with many introduced insects, the corn borer seems to be far more destructive in America than it was in Europe. The reasons for the apparent control in Europe have been given careful study by entomologists from the United States and, as a result, twelve species of parasites preying on corn borers have been imported, bred in the laboratories and liberated in fields infested with corn borers. In bringing these parasites into this country every precaution has been taken to import only insects absolutely harmless to our vegetation. Care has also been taken to leave behind all enemies of these parasites, for they in turn have their parasites.

> So, naturalists observe, a flea
> Has smaller fleas that on him prey;
> And these have smaller still to bite 'em,
> And so proceed *ad infinitum*.—*Swift*.

This parasite introduction has, of course, taken a great deal of time and care, but now more than two million parasites, in which are represented twelve different species, have been liberated at strategic points in the infested area of the United States. Of the twelve species liberated seven have been recovered, proving that they have become established and are at present busily preying upon the corn borer. Help by this method in the control of the

NO CORN BORER SURVIVES A GOOD BURNING

borer will of course be a long process and at present less than 1 per cent. of the borers in the field are being parasitized by these foreign insects.

An effective control of the borer required something giving quicker results. Spraying did not fill the bill, for the borers were inside the plant where they could not be reached during practically all their life. Sprays are known which would kill the eggs, but they are deposited over such a long period of time and are so difficult to reach by the best spraying methods that the number of sprayings necessary would be out of the question. Trap lights, traps and baits were also tried and proved ineffectual.

It was observed early in the corn borer investigations that a certain amount of infestation seemed to be evaded by late planting. However, the agronomists have figured that, because of reduction in yield due to late planting, a 20 per cent. loss from the corn borer must be experienced before it will be profitable to plant corn late enough to evade infestation.

There was, however, one weak spot in the life cycle, the hibernation period, spent during the fall, winter and spring in old corn stalks, stubble and other pieces of corn plant of no use about the farm. Practically all the borers in the field are then in the remnants of the corn crop or débris in the corn field, especially in the Great Lakes area. If all this can be effectively disposed of the borers are destroyed with it.

The surest method of destroying this material is burning. No borer survives a good burning, although it has been known to survive freezing and

other hardships. If all the old corn stalks, and pieces of corn plant, both in the field and about the barnyard, are thoroughly burned, the corn borer can be controlled.

Gathering and burning in some localities, however, require more labor than is practical and do not fit conveniently into the farm routine. In some cases, plowing all stalks, stubble, and other corn remnants and débris completely under has been found practical and is effective in destroying the borers. The plowing does not kill the borer, as it crawls to the surface after being plowed under, but if it finds no pieces of corn plant or other plant material on the surface in which to take refuge, it will most surely die from exposure, birds or other natural enemies. Experiments have indicated that at least 98 per cent. of the borers in a cleanly plowed field meet their Waterloo. The essential thing in this method of control is absolutely clean plowing, which requires a better than ordinary job of plowing. In plowing for corn borer control, the skill of the plowman is as important as the equipment. Wide-bottom plows are recommended, though a fourteen-inch bottom plow with attachments for covering trash has been found to give satisfactory results.

As the corn borer spreads west over the great corn belt, farmers will have to make the necessary adjustments in their regular farming practices to include corn borer control measures. One efficient piece of equipment in caring for the control problem is the silo. Those that escape death in the silage cutter are killed by the fermentation that occurs in the silo. Those practices which will have to be included in the regular farm routine and that will be adopted by farmers in the wake of the borer are the more general use of the silo, the use of husker shredders, low cutting in harvesting corn, plowing under corn stubble or standing stalks and the feeding, shredding, burning or similar disposal (before June 1 of each year) of all corn débris left around the farm.

One of the encouraging things about the work on this problem of European corn borer control has been the cooperation received from every side. Farm machinery manufacturers have from the first attempted to put on the market equipment suitable for corn borer control and within the reach of the farmer. This effort has produced the sixteen-inch and eighteen-inch bottom plow now on the market, which does a good job of plowing standing cornstalks and stubble completely under. The low cutting attachments for corn binders are now on the market and are being further perfected. These attachments will cut the corn to within two inches of the ground, which is considered satisfactory for corn borer control. Engineers, entomologists and agronomists are now at work on a corn combine which is so designed that it cuts low, picks and husks the ears and cuts or shreds the fodder in such a manner that a high percentage of the corn borers are destroyed. Much is expected of this type of machine as an important factor in corn borer control in the corn belt. There are being developed more efficient rakes for raking up last year's corn débris, portable burners and other pieces of equipment which will lighten the burden of corn borer control for the corn grower.

As previously stated, when the danger to America's corn crop was brought to the attention of the Congress in 1927, $10,000,000 was appropriated for a clean-up campaign to try to check the spread and cut down the increase or possibly reduce the number of borers in heavily infested areas. To make the campaign effective, about 2,500,000 acres of corn had to be cleaned up and more

PLOWING IN STANDING CORN STALKS WITH 18-INCH PLOW (JUNE, 1927)

than 200,000 farmers had to be reached and convinced of the necessity of a thorough clean-up. Every corn field in the campaign area had to be cleaned up and subsequently inspected in order to make the campaign worth while.

The plan of the campaign was to secure, where possible, the voluntary cooperation of the farmers in cleaning up their own fields and for the federal and state officials then to step in and, under state authority, to finish the job for those who either could not or would not do it. For the extra expense incurred by the farmer in cleaning up his fields the Federal Government proposed to reimburse him not to exceed $2 per acre. In some cases, the cost was actually more than this, but $2 per acre was considered a fair compensation in most cases and the appropriation was not sufficient to pay the actual cost in all cases. More than 185,000 farmers took advantage of this opportunity, cleaned up their fields, passed federal inspection and collected their extra labor fee.

Those fields which were not cleaned up by the farmers by May 15 were taken care of by clean-up crews operating under state authority, and the cost assessed against the farmer by adding it to his taxes. In most cases this cost has been assessed against the farmer and the states have collected a large percentage to be returned to the United States Treasury.

In putting on the campaign one of the principal limitations encountered was lack of time. The money became available on March 14, and thus only six weeks were left before it was necessary to start the compulsory clean-up in order to finish it before the moths began to fly in late June. In this period more than 200,000 farmers had to be told of the regulations, advised as to clean-up methods, given opportunity to do the work, and their fields inspected to deter-

mine whether reimbursement should be made. How well this was done can be judged from the fact that 185,000 farmers actually collected for the extra expense incurred.

Owing to extremely unfavorable weather for the clean-up operations and to the retarded development of the borer, the time for voluntary clean-up was extended from May 1 until May 15, when the clean-up crews stepped in and under state authority cleaned up the remaining corn acreage of about 68,000 acres scattered throughout five states.

As a result, entomologists estimate that more than 95 per cent. of the borers were destroyed when the campaign officially came to a close July 1, 1927, at which time borer moths began to emerge that year.

The real test of the success of the campaign, however, came with the fall survey to determine the resultant borer population and spread. It was found that the spread had been retarded very little, as can be seen by the map, largely because it was not practical to secure the clean-up of the border area, but the density of infestation had been kept down and commercial damage avoided.

Having shown the value of clean-up as a control measure and the futility of the best possible clean-up to prevent spread, it seems that corn borer control, which, like the control of other insect pests, is of local benefit, is therefore primarily the responsibility of the states and farmers in the infested area. At the same time it would seem that scouting, quarantine, research and education are activities likely to be of general benefit and, therefore, primarily the responsibility of the Federal Government. With a very admirable spirit of cooperation, such a program, calling for the mutual acceptance of responsibility appropriate to the various organ-

LOW CUTTING

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izations and individuals, is now in operation.

Though the corn borer is truly a grave menace to corn growers and now seems to be pursuing its inevitable way towards the corn belt, the outlook is not as dark as it first appeared. The clean-up method of control has been proved, by the 1927 campaign, as both effectual and practical in preventing commercial damage. Results of the 1928 clean-up effort show that the farmers are also both willing and able to practice control measures, once they are convinced that such are necessary. In 1928, in the absence of compensation in the areas under regulations, as many farmers cleaned up voluntarily as in the previous year when they received compensation for their extra labor. However, only the more heavily infested areas were included under the clean-up regulations in 1928 and, in most cases, the farmers were familiar with the corn borer and had personally seen evidence of the damage it was capable of doing.

As the borer spreads westward, it will be necessary for the farmers to change the farming routine to include a proper disposal of all old corn stalks, stubble and other remnants of the corn plant before June 1 of each year.

SHOWING THE KNOWN DISTRIBUTION OF THE EUROPEAN CORN BORER IN THE UNITED STATES

THE INFLUENCE OF ENGINEERING ON CIVILIZATION[1]

By Sir WILLIAM ELLIS, G.B.E., D.Eng.

In choosing the subject for my address I had to decide whether to devote my attention to some branch of engineering in which I have been actively engaged during my working life, alluding specially to some of the technical problems involved, or to treat of engineering in a less technical manner so as to interest any hearers or readers of this address who may not themselves be actively engaged in the engineering profession. Knowing that the Engineering Section would be addressed on technical subjects by very distinguished engineers, I have decided to devote my address to speaking of the very extensive part which engineering in its many branches has taken, and is still taking, in connection with the amenities which are associated so closely with our domestic life, and, indeed, our happiness. I shall hope in the course of my address to deal in some detail with the fact that each branch of engineering has added its quota to the comfort of our lives, and I think it may be claimed that no other profession has so direct an association with our modern civilization. The enormous increase in population during the nineteenth century, coupled with the segregation of that population in industrial centers, arising out of the extraordinarily rapid development of industry in this and other countries during that period, has introduced new problems in connection with health and transport, and it has been the task of engineering in its many branches to deal with these problems. It must be admitted that the great advances made in the knowledge of both medicine and surgery have played a very noble part in connection with improvements we all welcome in the health of the population, and in speaking of the part which engineering has taken in connection with public health I have no wish to lessen in any way what we all admire and respect, namely, the wonderful work of the medical profession in applying for our benefit the constantly advancing scientific and practical knowledge.

In the early part of the nineteenth century main roads did not exist in this country to any great extent, and these roads were in a very inferior condition. Pack horse transport was still in vogue, and up to 1850 a well-organized system of mail coaches was the principal means of passenger transport.

The introduction of railways and of steamers during the first half of that century led the way to an enormously increased demand for coal, iron and steel, and as the inventions of Sir Henry Bessemer and Sir William Siemens for making steel were developed, the necessity was evident to engineers and chemists for training schools to deal with the physical and technical problems involved in engineering and metallurgy, so as to arrive at a far greater accuracy, both in design and construction, than had hitherto been considered necessary or possible. I find on reading the history of those early pioneers, both in engineering and metallurgy, that they had to meet conditions similar to those which exist to-day, that is to say, they had to force their ideas on to a rather unwilling public in order to get them introduced, and in many cases they did not reap the

[1] Address of the president before the Section of Engineering, British Association for the Advancement of Science, Glasgow, September, 1928.

reward of their enterprise. Boulton and Watt had a desperate struggle for their existence. Stephenson had great difficulty in even getting his engine tried amongst those competing for the Liverpool to Manchester railway, and yet was the only successful survivor of the trials. To-day the fate of the inventor is little less hard. In many cases he finds his invention has been anticipated, and in others there is great unwillingness on the part of engineers and metallurgists to adopt the ideas because of the risk involved financially in developing the processes.

We have to admit, however, that the progress of industry depends very largely on the enterprise of deep-thinking men who are ahead of the times in their ideas. I may quote Dr. Clifton Sorby, F.R.S., as such an instance. He introduced by his researches the microscopy of steel, and yet it was many years before this became a recognized method of gauging the quality of all classes of steel. Another great inventor, whom we all respect and are delighted to have still in active work, is Sir Charles Parsons. I look back many years to the early eighties when Sir Charles put in years of research work in connection with high-speed engines before he successfully produced the steam turbine. Since that time he has devoted a large portion of his life to developing improvements both in the design of the turbine and the machinery for producing it, which have ultimately brought about its world renown, and his eminence in the engineering world was suitably recognized two years ago by the award of the Kelvin gold medal.

The technical societies in this country in the latter part of the last century realized that special attention would have to be devoted to an education which would combine a practical knowledge of engineering with a course of technical education of a high level. This was also associated with a preliminary examination to ensure that their students should have a sufficient grounding in general knowledge to enable them to apply themselves with success to the more intricate technical problems incident to their profession. This action on the part of these institutions has been fully rewarded by bringing into existence a body of highly trained engineers with special knowledge of the different branches of engineering, and, therefore, well able to lead our profession forward in the great developments which are still taking place in all branches of engineering.

Although in this address it would be out of place for me to discuss education in detail, I can not help feeling that the ground to be covered in engineering education is now so great that the universities will do well to apply education in general engineering problems for the first two years of a university course, and allow an honors degree to be taken in one or other of the special branches of engineering. I would urge that with the very short terms existing at our universities, in some cases only three terms of eight weeks each, it is unreasonable to expect a student to take an honors degree in three years if this covers all branches of engineering science. The alternative now being considered of meeting the difficulty by taking four years for an honors degree is, I think, open to grave objection, as it is delaying too long the date at which a young engineer is available to take up his first professional appointment and in fact become an earner.

Coming back to my original subject, can we say which branch of engineering has most directly been associated with modern civilization? I do not find that any one branch can claim the premier position. It depends, of course, very much on what we regard as the greatest essentials in life, and I presume we must admit that the greatest happiness of the greatest number must be taken as the

true gauge. In this case some of the luxuries and comforts of modern travel do not hold a primary position, much as we appreciate them. Such questions as purity and sufficiency of water supply for large cities, coupled with a scientific system of drainage, are the first essentials of health and comfort, especially in areas with large populations.

I will now turn to the different branches of engineering and illustrate as far as I can the benefits which these branches of engineering have introduced into the civilization of our present age. In doing so I would refer to the definition of engineering given in the royal charter of the Institution of Civil Engineers on its incorporation in 1828. The centenary of the institution has just been celebrated, and all engineers must be grateful to the principal of Edinburgh University, Sir Alfred Ewing, for the carefully thought out review of engineering progress in the last century, which formed the subject of the James Forrest address at the centenary meeting in June. The charter describes engineering as "a mechanical science dealing with the art of directing the great sources of power in nature for the use and convenience of man." The term "civil engineering" is a comprehensive one embracing all branches of the profession other than military engineering, but I propose to apply the words "civil engineering" in this address as dealing specially with drainage and irrigation works, harbors, docks, reservoirs, etc., dealing with railways under the heading of transport.

The various branches of engineering I propose to allude to shortly in detail are as follows: Civil engineering, as defined above; transport; shipbuilding, including marine engineering; mechanical engineering; mining engineering; electrical engineering.

Civil Engineering

The point which appears to me to stand out prominently in this branch of the profession is the fact that the structures to be dealt with are in many cases of an enormously costly nature, and have to be carried out with such careful study and comprehension of the varying problems to be dealt with so as to ensure permanent efficiency and safety in the future.

The great reservoirs and harbors of the world may be regarded as the cathedrals of engineering. The varying natural problems to be dealt with involve a very high level of technical education. In the construction of reservoirs, docks and harbors a considerable knowledge of geology is essential, and in harbor construction the varying effects of tides which have to be studied minutely have an important influence on the work to be undertaken. Throughout the world will be found monuments to the skill of the civil engineer and the very existence of the population in our large cities in health and comfort is the result of his work, for without an ample and reliable supply of water of good quality, both for personal and industrial use, and an efficient drainage control, our death-rate would indeed be very different from what it is. If we turn for a moment either to India with its great barrage enterprise, or Egypt, with the noble Assouan and Sennaar dams, truly outstanding works of the civil engineer, we find the prosperity of these countries largely resulting from the magnificent irrigation works which have been carried out there. Special development of produce growing in many countries is only being limited by the fact that insufficient irrigation works have so far been carried out. New Mexico and Arizona are two great provinces with potentially fertile land available for agricultural development, but they are so short of water that irrigation is an absolute necessity.

The large increase in tonnage of ocean-going vessels has resulted in the necessity for larger docks and harbor basins, and the development of railways all over

the world, many of them in difficult mountainous countries, has given the civil engineer a great opportunity in designing bridges for carrying this heavy traffic. Many of my audience will appreciate the magnitude of the new bridge over Sydney Harbor now being constructed by British engineers, and the Forth Bridge still holds its own as a masterpiece of British engineering skill, and the construction was in the hands of a Scotch firm well known in Glasgow. The new high-level bridge at Newcastle and the new Mersey tunnel are, I suppose, the most interesting civil engineering works at present in progress of construction in this country, in addition to the considerable dock extensions now proceeding at Southampton, whilst in Canada a very noble bridge is now being thrown across the St. Lawrence River at Montreal.

Transport

It may truthfully be said that the development of the potential wealth of any country depends mainly on the means of transport, both personal and industrial. I would allude especially to the great corn-growing countries, where the home consumption bears only a small relation to the possible production. The knowledge that there is efficient transport both by rail and for export by sea is the greatest incentive to the farmers to spend money in extensive cultivation with the certainty of a ready market for such production. Without mentioning any countries we probably have instances in our minds where inefficiency of transport facilities is absolutely blocking the progress of internal wealth in those countries. On the other hand, where railways are efficient and harbors well equipped with shipping facilities, we find consequent prosperity.

The comparison of travel to-day, both by land and sea, with my early journeys in Europe nearly fifty years ago emphasizes in my mind how much we are indebted to the engineer, in the way of personal safety and comfort and also prompt delivery of our products. A journey in the Balkans in the winter of 1881 when sleeping cars and restaurant cars were almost unknown, and when the largest vessel sailing from Mediterranean ports was in the neighborhood of four thousand tons, compares very unfavorably in speed and personal comfort with the facilities which are available to-day. The comfort and safety of modern travel is to my mind one of the glories of modern civilization. The forty thousand to fifty thousand tons Atlantic liner, embracing as it does almost every class of engineering skill, is not only an example of artistic beauty, but is one of the finest instances of human power combating the forces of nature. To be on one of these vessels driving into a gale at twenty knots is an experience never to be forgotten, and we are glad to realize what a large share the shipbuilding firms of Glasgow have had in the development of these large Atlantic liners.

Railway transport has also made great progress in all measures affecting personal safety and the efficient carrying of our various products. The railway engineers have every reason to be proud of their management of the complex organization represented by the great railway systems all over the world. We are personally much safer traveling in an express train than we are crossing the streets of a great city, and I think we may justly be satisfied by the fact that in no country do the railways afford more comfortable or more rapid traveling facilities than in our own. The railway engineer has still some very interesting problems to face. Heavier and more powerful locomotives are the natural outcome of the demand for heavier freight trains. The civil engineer of a railway company can not deal with this problem without strengthening bridges and improving the condition of the

permanent way. All these developments involve large capital expenditure, which it is not convenient for many railway companies to undertake at the present time.

The question of the railway companies developing motor services to meet the competition of road transport has been the subject of legislation during the present year. I think the public acquiesce generally in the feeling that as the railway companies pay such a large proportion of the rates of the districts through which they have traveling facilities, it is only right they should develop road transport in connection with their traffic in view of the serious competition which they have to face. Transport by road has undoubtedly been very much facilitated by the large sums which the Ministry of Transport has had available for the purpose of remaking and generally improving our main roads, and careful study has been devoted of late years to the selection of suitable materials for this purpose. Consequently, in the last ten years there has been an immense improvement in the quality and design of our main roads, more so than in any previous decade.

It appears to me that one question which has hardly been touched to any extent at present is the desirability of increasing very largely the number of by-pass roads to divert heavy traffic from passing through large towns, and even villages, which are now suffering severely from congestion of traffic in their altogether too narrow thoroughfares.

On looking back a few years to the old system of horse-drawn tramways, we must surely be grateful for the benefit accruing to many thousands of our working population arising out of the introduction of electric tramways, enabling them to live in many cases in much healthier surroundings.

Naval Architecture

This comprises shipbuilding and marine engineering and represents a very important part of my subject, dealing, as it does, with the transport by sea and lakes of food and materials, and with the comfort and safety of the many thousands of passengers traveling to and from this country. The wooden vessel in the early part of last century held its own very stubbornly against the introduction of iron or steel vessels, and the mechanically propelled vessel had to fight very hard to oust the very efficient sailing vessels which were then carrying the trade of the world. I imagine that some of my audience with artistic tastes will not be willing to admit that the beauty of the present type of mechanically propelled vessel is comparable with the picturesque five- and six-mast sailing vessels which we used to see in our earlier days. This country has undoubtedly been the pioneer in the building of large warships and passenger liners, also in the development of the very large horse-power therefor. The considerable increase in the tonnage of ships brought with it the necessity for a corresponding increase in the mechanical appliances in connection with their construction. The trial runs carried out before a new ship is taken over by her owners are a severe test of the excellence of workmanship. They are a necessary test to ensure that long voyages of five to six weeks with machinery running continuously at nearly full power can be undertaken without fear of trouble arising from heated bearings or other causes. A new ship may be exposed to such rough weather on her first voyage that unless her plating and riveting are carried out in a first-rate manner, she may arrive in her first port in a damaged condition. Some of us still remember during the war how new ships, built in other countries, were seriously damaged owing to the workmanship not being of a sufficiently good character. The handling of thick plates of large surfaces and the riveting of them satisfactorily to the stanchions still remains a laborious and trying piece of work for those

engaged upon it, although mechanical means exist to some extent. Glasgow has taken a leading part, providing men who in all weathers and under conditions rendered difficult by the magnitude of modern vessels maintain the high level of efficiency which is represented in the manufacture of these large hulls. The vessels of the greatest tonnage built on the Clyde have been the *Aquitania* (46,000 tons) and the *Lusitania* (32,500 tons). Other large vessels built in the British Isles have been the *Olympic* (46,439 tons) and the *Mauretania* (30,696 tons). Since the war there has been a lull in the building of liners of large tonnage and horse-power, caused, no doubt, by financial considerations, but it is gratifying to know that two large ship-owning companies are at the present time contemplating building vessels up to one thousand feet in length with a speed of over twenty knots.

Shipbuilding is especially interesting inasmuch as it combines in one structure the varied efforts of almost every class of artisan dealing with both iron and steel and cabinetmaking and woodworking generally, in addition, of course, to the large and varied amount of mechanical engineering. In marine engineering the last fifty years have, indeed, a most interesting record of progress, and in very early years such firms as Humphreys Tennant, Maudslay, Son and Field, and other firms no longer in existence, introduced a measure of precision into mechanical engineering probably not then existing in any other branch of the industry. High and low pressure triple expansion engines held their own for a considerable period, and it was, I suppose, the interesting trials of the *Turbinia* which brought about the first change from this method. It is an interesting fact that our fellow member, Sir Charles Parsons, to whom I have already alluded, should live to see such successful development of his patent, and a recent paper read by him and his coworkers describes in a very interesting manner the gradual developments and changes in design in turbines up to the present time. Such developments range from the *Turbinia*, which had a displacement of 44½ tons with 2,100 h.p., to the battle cruiser *Hood* of 41,200 tons and over 150,000 h.p.

The introduction of geared turbines, so as to arrive at relatively efficient speed as between engine revolutions and propeller revolutions, has brought about valuable economies and helped the turbine principle to maintain its reputation. The development of internal combustion engines for marine purposes has made great strides in recent years. Various types of these engines are already in active service, and a horse-power of 36,000 on four propellers has already been achieved with efficiency; probably the limit has not yet been reached. The use of oil instead of coal on board ship, especially for passenger purposes, represents many advantages, and any one who has visited the stokehold of a large passenger liner with the hundreds of men stoking with coal must realize the immense advantage, both physical and otherwise, which results from oil burning directly on the boilers. All inconvenience caused by dust in recoaling is avoided, and the boiler tending is carried out by young mechanical engineers, doing away with all the labor required by coal burning. In a vessel of large tonnage the saving in wages and maintenance of several hundreds of stokers represents an enormous economy in many directions. The question of larger horse-power or electrically driven ships is one of the problems which marine engineers are at present turning their minds to.

A new development which is now being introduced is the use of considerably higher steam pressures in boilers. The first application of this was the *King George V.*, a boat built last year on the Clyde, and our section has been

favored with a paper from Mr. Harold Yarrow dealing with some of the problems which have arisen in introducing high pressures. As you will have gathered from his paper, these problems are not solely those of the engineer who has to build the boilers. They are closely associated with steel and metallurgical questions incident to the special manufacture of parts of the boilers owing to the much greater strength required. Many of my audience, no doubt, have been interested in the valuable information we have received from the paper in question.

The defense of our country depends very largely on the efficiency of our warships, and it is impossible to speak too highly of the wonderful reliability shown by the vessels of our navy during the late war, thanks to the efficient engineering service in our navy, and the determination of the various builders in this country to produce vessels representing the highest standards of engineering efficiency. Our country, I hope, realizes how much we owe to the engineering branch of the navy for the well-proved efficiency and courage of its officers and men of all ranks in the late war. I believe that no vessel of our enormous fleet failed in action owing to breakdown of machinery, and the conditions under which the engineering staff find themselves in active warfare must be a severe strain on their courage. The response to the sudden call on the two battle cruisers, which had already been on active service for a considerable time, to make the voyage at full speed to the Falkland Islands to engage the German fleet, represented an engineering feat of a very high order.

In the mercantile marine we have great cause for thankfulness in the developments which have taken place, resulting in a very much greater comfort at sea. These efforts are naturally limited by the sizes of the harbors between which the vessels have to trade, but when we come to ocean liners the study which naval architecture has given to the production of these great vessels has resulted in our being able to visit different parts of the world with a comfort which is equal to that provided by the best hotels in any of our great cities. Shipbuilding and marine engineering have indeed taken a noble part in assisting the march of civilization and adding to our comforts in every possible way.

I wrote this part of my address on the voyage to New York on the 46,000-tons liner *Aquitania*. What a triumph of enterprise to the Cunard Company and to the naval architect and marine engineer such a vessel represents. I was watching her driving into a northwest gale from the boat deck during the day, a magnificent battle between nature's power and human skill, a sight which arouses one's admiration for the great minds who have raised engineering to so supreme a height and added so greatly to the advancement of civilization.

What does this wilderness of sea portray?
A mighty struggle, constant day by day,
'Twixt human skill and nature's changing mood
The ceaseless roar of North wind's subtle blow,
The varying power of waves that ever flow.
Such is man's battle 'gainst this angry flood.

Mechanical Engineering

It is difficult to regard mechanical engineering literally as a separate branch of engineering, for although numerically, I suppose, the mechanical engineers exceed the numbers of any other branch, nearly all their duties are associated with other types of engineering.

In connection with civil engineering all the plant occupied in harbor, dock and railway construction is in the hands of the mechanical engineer. Also in transport and marine engineering the mechanical engineer is largely engaged in the engine building of both locomotives and marine engines and other types

of auxiliary machinery for these purposes.

In electrical engineering, although this branch no doubt includes engineers without mechanical training, I would venture to say that the engineer is in an infinitely stronger position if he has received some training first as a mechanical engineer and specialized in electrical engineering afterwards.

A further important branch of the mechanical engineer's work is represented by the maintenance of machinery in the large steel works throughout the country and in the mills and factories of all descriptions. The directors of these companies are largely dependent on the advice of the engineer-in-charge in giving consideration to developments and the introduction of new types of plant to maintain production on an economic basis.

In mechanical engineering I must include the very important subject of machine-tool construction, a branch of engineering which has made very great strides and introduced many changes of design to meet new requirements in the last thirty years. Mass production on an economical basis in many industries has been the direct result of various tool-makers being able to produce special tools confined to the production of thousands of identical articles of a complicated design. I refer to articles produced at a cost of one tenth to one twentieth of what would be possible without machine tools specially designed for the purpose.

The introduction of high speed tool steel enabling far heavier cuts to be taken both by lathes and planing machines has rendered obsolete a large quantity of machine tools throughout the country, and the introduction of the electric drive has also brought about great changes in the design of machine tools. We hear to-day of some works in other countries without a single machine tool at work of prewar date, a most desirable state of things, but one which, unhappily, the economic circumstances in this country have rendered impossible up to the present time. In principle we have to admit that with our relatively high wages and general charges on industry, taxation, etc., it is not economical to continue to use machine tools which can be superseded by modern tools doing a greater volume of work in a given time, but many firms throughout the country are only able to act on this principle gradually owing to financial reasons.

We hear very strong rumors of the advent of a new type of tool steel, if it can be called steel at all, which is going to bring about a greater change in output than was represented by the introduction of high speed steel some years ago. If this becomes an accomplished fact it is good news for the toolmakers throughout the country, although it may not be equally welcomed by the many large firms already equipped at considerable capital charge with reasonably modern tools. With such keen competition, however, and the power of over-production at present existing in the country, no firm can afford to ignore the march of progress and will have to recognize the necessity for introducing machine tools of the most efficient type even at considerable financial sacrifice.

May I make a suggestion to the toolmakers in this country? When we are putting down an important new machine tool I find the makers will give every possible help in meeting our requirements in design and output, but they rarely follow up and ascertain what the real performance of the tool has been. To many of them "no news is good news." I think this is a mistake on their part. How many improvements and modifications, probably saving their clients money, could be made if they would periodically send the designer or chief draughtsman round to the works where these machines are actually at

work and ascertain at first hand from the foreman and even the workman what criticisms they have to make, and accept for careful consideration any suggestions that may be put forward based on personal knowledge of the output of the machine.

Mining Engineering

In dealing with this section I propose to confine myself to coal mining, so as to shorten what I have to say, and also to be able to apply myself more closely to the development of coal mining as affecting civilization.

Prior to the introduction of modern means of transport and the development of the iron and steel trade, the production of coal in this country, both in the aggregate and per colliery, was very small, and, consequently, the amount of virgin coal face exposed at any one time in a colliery was quite moderate. Therefore, the effusion of gas was not sufficiently large to introduce a serious danger to men working with naked lights. Ventilation was carried out by means of a furnace in the bottom of the upcast shaft, the draught being sufficient for ventilating the moderate area of the workings. Increased production necessitated the adoption of mechanical means of ventilation and large fans were installed. Science had a large share in making colliery development on a big scale possible by the introduction of the Humphry Davy and other safety lamps. These warned the miners of the presence of gas and consequent danger. The much heavier tonnage produced in a given time necessitated the introduction of large horse-power winding engines, and also of wire ropes which would be sufficiently pliable to pass over the pulleys and headgear, and also be strong enough to carry, not only their own weight which in a shaft of 500 yards is not inconsiderable, but, in addition, a loaded cage involving a weight of thirty tons or more.

A sufficient supply of coal at a moderate price is a matter of interest to every inhabitant and manufacturer in the country, and, therefore, any engineering devices which have been introduced to ensure comfort and safety of the miners and at the same time to give us our coal supply for manufacturing and domestic purposes at a moderate price, are of interest to every one. Although we unhappily know that colliery explosions occasionally occur with very dire results, and regret the many accidents to miners arising out of falls of roofs, etc., those of us who are conversant with coal mining matters realize how much science and engineering have done to lessen the risk under which the miners work. I believe that the public feel that one of the great risks is in winding the men up and down the shaft each day, and yet the careful supervision of winding arrangements, inspection of ropes and general regulations for the safety of the men are such that, so I am informed, it is only one man in forty millions who suffers an accident from this portion of the miner's duty.

The introduction of vertical ropes as guides to the cages, instead of wooden or steel guides, affords a safe and smooth running of the cages at sixty miles an hour with no more vibration than we experience in traveling in an express train at the same speed. Underground haulage has been everywhere adopted, so that the use of men for this arduous work, and, to a great extent, ponies also, has been abandoned. This underground haulage is largely carried out by compressed air engines placed underground, as in many pits it has not been felt safe to introduce electric power for the purpose except in the immediate neighborhood of the shafts. It is true that the electrical engineer has gone a long way in lessening the liability to sparking, and in enclosing the motors so as further to lessen this risk. We are still left, however, with possible danger

caused by the cables along the main roads, which however carefully placed are still liable to be damaged by unexpected falls of roof, thereby introducing a potential danger which is difficult to eliminate. At the coal face the engineer up to the present has not been able to do much to lessen the hard manual labor of the working miner, but in thin seams, say up to three feet thick, where manual work on a solid face would be almost impossible, coal-cutting machinery (in which a well-known firm in this city has successfully specialized) has been introduced, thereby lessening enormously the manual work of the miner. I venture the opinion that the introduction of machinery for this purpose has not yet reached its limit.

I regret that more members of the public do not take the opportunity of going underground and seeing the men at work at the coal face. On my various visits I always receive a warm welcome from them, and it is a real education to see what the engineer has done, and under what conditions the men work in producing an article on which we so much depend for the comfort of our daily life.

Electrical Engineering

This branch of engineering covers a very wide range of subjects and affects our social life almost more intimately than any other type of engineering, except perhaps the supply of good water and efficient drainage installations. It is impossible for me to attempt to cover the whole range of subjects embraced in electrical engineering. Telegraphy, telephony, wireless, electric lighting, electric heating, electric driving and electric power in their various ranges all enter into and affect the comfort of our domestic life. In considering this branch of engineering as a whole I find it very difficult fairly to divide the credit for its development between the pure scientist and the electrical engineer. The researches and experiments in the early part of last century on the part of Wheatstone, Faraday and Lord Kelvin, and later, coming to our own time, of Sir Oliver Lodge, Senator Marconi and other eminent scientists, have undoubtedly prepared the road to the later applications of electricity for domestic and engineering purposes, and no electrical engineer to-day can possibly efficiently carry out his duties without a greater knowledge of pure science than may be regarded as essential in other branches of engineering. It is interesting at this meeting in Glasgow to recall that it was at the British Association meeting in this city in 1876 that Graham Bell, in conjunction with Lord Kelvin, brought to the association's notice the telephone, and, further, the fact that at the Plymouth meeting of this association in 1877 I shared with many eminent members of the British Association the interesting privilege of telephoning from the saloon to the bridge on the excursion steamer, with Professor Graham Bell on board, going to and from the Eddystone Lighthouse. I allude to this fact because in those days it was regarded as a wonderful scientific invention which fascinated the most eminent scientific men. Yet to-day we take it all for granted, and hardly realize the comfort and convenience that the introduction of the telephone has brought into our lives.

I admit that the introduction of wireless telephony and telegraphy has amazed the world to a greater extent than that of the telephone, and it is certainly more within the capacity of the pure scientist than of the engineer to explain the scientific problems involved. I am not going to state whether the introduction of wireless broadcasting into our homes is an amenity or not, *chacun à son goût*, but when we turn to the application of wireless telegraphy we accept without hesitation the benefits it has brought into the world. It is im-

possible to say what number of lives have already been saved by boats in distress having been able to secure help from other vessels by means of wireless communication.

The development of electricity as a mechanical driving power was very slow up to a certain date. For instance, I went by electric train from Berlin to Charlottenburg in the spring of 1882. The running of the railway appeared to be quite satisfactory, and yet it was at least ten, and I think fifteen, years before any real development took place in the way of electric railways or trams, the difficulty, I believe, being in producing satisfactory dynamos on an economic basis. The first electric railways in this country, so far as I know, were the Liverpool Overhead Railway in February, 1893, and the Liverpool to Southport Railway in April, 1904. The practicability of electric driving on main lines is still a matter under discussion. The only country which has wholeheartedly adopted this system is Switzerland, a country which has undoubtedly been influenced by the uncertainty of obtaining a uniform supply of coal at reasonable prices, coupled with the fact of an efficient and ample supply of water-power for their generating stations. The Barberine reservoir, which has now been completed, and the large reservoir at the Grimsel Hospice now under construction are fine examples of civil engineering work carried out for the purpose of developing electric current for the Swiss railways.

In this country considerable developments are taking place on the various main lines, but engineers are at present concentrating on the use of electric driving mainly for suburban traffic, and not at present on main line long-distance expresses. It is probable that the great extension of high-power installations throughout the country contemplated by the electricity commissioners will render possible a more extensive use of electric trains on our main lines.

The application of electricity for driving purposes in the various large works in this country made very rapid strides as soon as electrical machinery for the purpose was available. I remember showing to a former president of this association, Sir William White, the first set of Belliss and Morcom engines we had installed in a works in the Midlands, the various machines in these works at that time being driven by steam engines in different shops and line shafting. Sir William said to me then, "Do you realize that within ten years every machine in these works will be electrically driven?" I think few engineers realized at that time that electric driving would replace so rapidly the existing methods. Apart from the economy represented by its introduction the change enabled the management to register the amount of power used by each type of machine under varying loads of service, a circumstance which was impossible with belt-driven machines, when the power varied according to the tightness and width of the belt. The greater efficiency, however, is really represented by the fact that in a large works electricity can be produced in bulk at a central power station at a low rate of cost, and the loss in distributing to the various departments through high-tension cables and transformers to lower voltage in the different sections of the works is insignificant compared with the saving represented by a consumption of coal and a cost of maintenance far below what is possible with direct steam driving. Electricity has in some measure been introduced into mining engineering, as I have mentioned in the mining section; electric winding engines have been adopted with satisfactory results; but as the fuel supply for steam raising at the various collieries, especially where coke ovens are installed, is much less costly

for providing power than in a works without such auxiliary facilities, the economy in the use of electric winding *versus* steam is naturally not so great.

The public, I think, fails to realize that electric lighting for domestic purposes, if charged at a reasonable rate, does not represent any real charge on the household. It is so clean in its application that, in my opinion, the necessity for cleaning and decorating which is avoided in many cases represents a greater saving than the amount paid for electric light. In addition we have the great advantage that it does not burn oxygen, and therefore we have more healthy conditions in our rooms compared with any other method of lighting. I feel sure that those who have introduced electricity into their houses for the purpose of cooking and hot-water supply will never go back to the old system of kitchen fire for this purpose, owing to the former's efficiency and cleanliness in application. It appears to me that all that is wanted for a much larger use of electricity domestically is a reduced charge by the various supplying companies and corporations at least to the level which exists in many of our cities already. It is hoped that the work of the electrical commissioners in installing bigger units of power throughout the country may bring down the cost so as to place electricity within the reach of every householder.

Since I roughed out this address it has been my privilege to make a journey across America from New York to the Pacific Coast, and return through the Rocky Mountains and Canada, and throughout my journey I could not help realizing how large a share engineering in its broadest sense has taken in developing these wide regions. First comes the railway as a through communication between east and west for three thousand miles. Gradually settlers come and farming and lumber work commences, their progress only being possible with the aid of railway transport. Gradually small towns spring up, requiring the assistance of engineers for water and drainage. In the torrid provinces of New Mexico and Arizona the water question is a very serious one, and large irrigation schemes will have to be introduced. At Grand Canyon, for instance, the water for household and farm use is brought nearly two hundred miles by train in large special wagons. Then mineral wealth is discovered, and the mining engineer appears and requires his varied plant to be brought by railway from the manufacturing centers. In the mountainous parts of the country large hydroelectric plants are being developed, thus calling on the electrical engineer for his services, and I might quote many other illustrations of a similar nature.

Yes, ladies and gentlemen, those of us who are spending our lives in engineering work may justly be proud of the large share the members of our profession are taking in promoting and advancing the civilization of the world, and thereby bringing happiness and prosperity to many thousands of our fellow countrymen.

I realize that within the limits of this address I have only been able to touch to a very limited extent on the association of the different branches of engineering as affecting our civilization. I hope, however, I have said enough to interest my audience in a side of engineering that is not often brought out, and that those of us who are actively engaged in engineering may earn the respect and confidence of our fellow citizens.

EDUCATIONAL TROBRIANDERS AND THE PROFESSORIAL ILLUSION

By Professor JOHN M. FLETCHER
TULANE UNIVERSITY, NEW ORLEANS, LA.

MALINOWSKI, the Polish anthropologist, tells us that the Trobrianders, who inhabit a coral archipelago of the South Sea Islands, have never been able in their thinking to connect the birth of a child with the antecedent procreative act. Children, according to the belief of these people, come from Tuma, the Island of the Dead, a land populated by the souls of persons who have died on earth. On arriving in this land the souls acquire the power, once possessed by them but lost, of renewing their youth. After a round of rejuvenations the souls may, with the guidance of Baloma, the presiding deity of the Island, return to their original earthly abode by entering the bodies of women of their original clan or sub-clan.

If we are disposed to follow the Socratic analogy of thinking of the business of instructing the youth as a sort of midwifery of ideas, we may find ourselves to be closer akin to the Trobrianders than we may imagine. Indeed we are, it seems, in quite as primitive a stage in respect to the growth of minds as are the Trobrianders in their idea concerning the growth of bodies. That we know little concerning causes and effects in education is a conclusion which we are about to be shocked into confessing. Some of our shockers are even going so far as to insinuate that we have not reached the stage of being intelligently concerned about the matter. President Faunce, of Brown University, has recently been quoted as saying, for instance, that "nowhere else is education so pointless and aimless, so blind in its objectives, so indifferent to any specific outcome, as in America." In the light of this significant confession it is surely in order to ask what it is that gives such authority and solemnity to the requirements set up by curriculum committees.

Are we sufficiently familiar with mental embryology to be trusted with the authority in these matters which such committees consider to be their inherent right? In order to make clear the issue involved in this query let us, after the fashion of lawyers, put the hypothetical question: Suppose that before a representative committee on graduation requirements we were to lay the candidacy of a certain young man. Suppose that the young man in question knew no Latin, no English, no modern language, no Roman and little Greek history, very little mathematics and physics, no algebra, no calculus, very little about human anatomy and physiology, very little about astronomy, practically nothing about chemistry, geology, biology or botany, and his entire library could be carried in a wheelbarrow. To award an academic degree in spite of a confession of such ignorance as this would turn our educational system topsy-turvy. Yet, let me confess, this is not a hypothetical but a concrete case. Plato, according to L. P. Jacks,[1] would, if living to-day, be compelled to make just such a confession. Was Plato an educated man? Can we with all of our latitude in curriculum making grow such a mind as his?

The upshot of the situation seems to be that we are in a pre-scientific age respecting education and we are attempt-

[1] *Atlantic Monthly*, Febr., 1924.

ing to function as if we were in a scientific age. Scientific method, wherever applied, presupposes the understanding of cause and effect and a certain degree of control in the manipulation of causal factors. Pre-scientific empiricism proceeds by the method of trial and error, and has no criterion of the correctness of its methods except the goodness of the end results. I can not accept the criticism of modern education that would have us believe that menticulture was once understood but has become a lost art. Those who have such faith in ancient ways may be interested to read an old Latin saying quoted by Paulsen in his book on German universities, a saying which has a distinctly modern flavor though it dates as far back as the Middle Ages: *Sumimus pecuniam et mittimus asinum in patriam.* Probably the chief difference between ancient and modern methods of turning out this sort of educational product is that we have made some progress in quantity production.

The urge toward scientific control in education has undoubtedly been present. We seem, however, to be grossly in error as to the extent to which we have succeeded in effecting this control. We have been searching for a sort of synthetic formula of education. In the more scientific methods of recent years we have turned away from the consideration of the relative values of various cultural products of civilization, and have centered attention upon the learning personality and its learning processes. Pursuant to this aim we have formed and are still forming theories as to the essential components of the human mind. But when, in acting on such theories we attempt to fashion a mind as we have, by following a similar method, learned to produce synthetic camphor or rubber, our efforts are, according to many observers, not always successful. In our faith in the analytic methods of science we have broken the human mind into many sorts of fragments, now of sensations and their residues *à la* John Locke, now of primitive instincts *à la* G. Stanley Hall, now of muscle twitching *à la* John B. Watson, but as in the case of the tragedy of Humpty Dumpty, we have not been able to get these fragments together again into a going concern. Yale, according to press reports, acting on the assumption that its present seniors are educated, seems to be endeavoring to find out from them through questionnaires how it happened. These seniors are called upon to give testimonials as to what they consider to have been the most beneficial studies pursued by them in their college careers; a case of educational empiricism, of judging the method by the character of the end products. Society in general seems to be able to recognize an educated man when one comes along, but how to produce them we are still endeavoring to learn. The factors that enter into the making of an educated mind are so multifarious and they operate over such a wide span of time that it is difficult to make connection in our minds between causes and effects. Hence even primitive empiricism is difficult to apply. What we call the stupidity of the Trobrianders about the birth of children is different from our own helpless ignorance as to cause and effect in education only in degree.

In the present state of failure of our attempts at developing scientific educational formulae one may find good ground to advocate a frank adoption of out-and-out empiricism as the best present guiding principle. Successful empiricism is better than an unsuccessful scientific formula. What we have at present is a mixture of the two, and hence neither can succeed, and hence, further, neither can be disentangled from the other in tracing the responsibility for success or failure, as the case may be.

The chief difficulty in the way of adopting an empirical basis of estimating the value of educational methods and materials is that educated Yale University seniors and educated college professors alike when called upon to tell how they got that way are subject to what may be designated "the professorial illusion," so named because college professors seem so subject to it that they almost deserve the distinction. The professorial illusion, like any other sort of illusion, is a parallax or distortion of judgment caused by an egocentrism of viewpoint. Man originally conceived a geocentric universe because he has an egocentric mind. The hub of the universe sticks out in our own villages because the locus of all hubs is the individual mind. If one makes his bed in hell this same hub will be there. Provincialism is a mental, not a geographical, phenomenon. We all, says Bacon, have a cave or a den of our own, "which refracts and discolors the light of nature."

To apply: All men, whether learned or unlearned, have their educational philosophies. With both the learned and the unlearned these philosophies represent the formulation of personal experiences into principles of universal applicability. If one doubts the existence of such philosophies he needs but to do a bit of psychoanalytic work on his own accord. Let him choose his professorial victim and provide the simple paraphernalia of a pipe, an easy chair and the softened light of the study lamp. The technique to be employed is simple. The first and sometimes the only step in the procedure is to introduce the question as to how the victim came to be what he is. Once the stream of reminiscing and philosophizing has begun to flow only good listening is required. The listener will soon be rewarded by detailed accounts of how circumstances, whether good or bad, wealth or poverty, social contacts, early parental discipline, whether severe or *laissez faire*, everything, in short, of whatever kind, have contributed to make out of the subject of the test the man that he is.

Now, let me pause here to say in parenthesis that this universally human reaction is a beneficent one, and undoubtedly has its biological uses. In the days when men were not afraid of being called vitalists they used the phrase *vis medicatrix naturae* to describe the disposition of a living organism to take care of itself. Molière, for instance, said that physicians amused the patient while God did the healing. It is not scientifically fashionable nowadays to speak of the "healing power of nature," but we may describe the same phenomenon as the capacity to manufacture anti-bodies to combat disease, when we are talking about physical ills, and when we are talking about mental ills we must adopt the modern lingo about rationalization, defense reaction, etc. At any rate we have here a case where Nature, contrary to what Tennyson said about her, is found to be not at all "careless about the individual life." The mind, in short, like the body seems to resist disease, disorder, annihilation. Injurious memories, thoughts about failures and the emotions connected with such thoughts, either become covered by the veil of amnesia, or else, in the pipe-smoke of retrospection, have a new light thrown upon them, so that we may live with them mentally without injury or pain. It is by virtue of this beneficent power that healthy minds of all ages have achieved the triumph of seeing sweetness in the "uses of adversity," and of welcoming life's rebuffs.

Like all other beneficences of nature, however, this reaction tendency has its errancies, of which the professorial illusion is one. It is not true that the history of the world is the best criterion of what should have been. The world as well as human lives may be assumed to

have been better off if some things had never happened. Most people will accept this conclusion when applied to the history of the world, but when thinking of their own personal history agree with Samuel Butler's character, Pontifex, who said: "As I look back upon it, I respect myself more for having never once got the best mark for an exercise than I should do if I had got it every time it could be got. I am glad Skinner (the headmaster) could never get any moral influence over me; I am glad I was idle at school, and I am glad my father overtaxed me as a boy—otherwise, likely enough, I should have acquiesced in the swindle, and might have written as good a copy of Alcaics about the dogs of the monks of St. Bernard as my neighbors."

Once an observer gets interested in collecting specimens of this fascinating mental phenomenon they will begin to bob up in the most unexpected quarters. Example: A certain educational authority of the Mid-West was heard talking to a group of college students in a Sunday school class. Being in a mood to moralize, he fell to telling them about why he turned out so well—of course no one ever puts it so bluntly as that. The thing for which he felt the greatest gratitude was the fact that his parents in the early years of his life sent him to a school where only two things were taught, namely, music and manners. One of his graduate students, on hearing this, remarked: "I do not know how much *music* he knows."

The pedagogical damage wrought by this personal parallax of judgment results not only from the fact that we may be mistaken as to what may have been the best thing for ourselves, but more especially from our insistence, if we have the authority so to do, that others shall be required to do what we have done. We may possibly be correct as to what particular studies have contributed to our intellectual development, and still have no right to conclude that these same intellectual pursuits will contribute a same amount of benefit to all others who may follow them. We are, in short, in a pre-scientific stage of knowledge concerning curriculum formulation, although when we have presented to us, say, for education, a human mind, presumably empty, we assume that by putting in a little of this subject and a little of that we shall produce an educated mind. The various stuffs in our educational dispensaries are, by common tradition at least, labeled according to the effects they are expected to produce. It is, surely, fair to presume that if we expect these various subjects to produce predictable effects of a certain kind in the students who study them, the teachers, who may be presumed to have mastered such subjects, ought to exemplify such effects in maximum degree. If they do not, then we must be mistaken as to what such subjects will do for students.

There is an old story that was current during the suffragist movement in England that a monocled son of nobility gravely delivered to an ardent suffragette one day the opinion that women should not vote because it tended to make them too masculine. The suffragette replied that voting had apparently not had that effect upon him. When our bespectacled pedagogical gentry, under the spell of professorial illusions, to which we are all subject, are gravely delivering opinions and making laws in curriculum committees, it might be a wholesome thing for our suffragette, like Portia, to come into court and take the part of defenseless youth. Few of us who teach have the courage to meet such situations in so prompt and so effective a way as she met hers.

Viscount Bryce some years ago dichotomized the subject-matter of education into "external objects, animate and inanimate," on the one hand, and "the

products of thought," on the other. The one he called the domain of science, the other that of the humanities. The former is qualified, he thought, to give knowledge and practical efficiency; the latter to give culture. To his mind one may as well expect to gather grapes of thorns or figs of thistles as to expect culture to result from the study of "tissues," "electrons," "sodium chloride" and "cephalopoda." In spite of the fact that it is to these despised natural phenomena themselves rather than to books written about them that the liberalizing minds of all ages have turned for their inspiration, Bryce would have us believe that educational products are determined by the character of the subject-matter, that the study of recorded thoughts will give us one result, and the study of things will *per se* give us something quite different.

The ancient and honorable discipline of mathematics has always arrogated to itself the peculiar quality of developing the minds of its devotees. But for this assumption nine tenths of the mathematics now in our curricula would be eliminated. When a teacher of that subject takes this position either explicitly or implicitly, there should be present someone as wise and as courageous as the suffragette previously mentioned to say, "What a whale of a mind you must have!" Now, indisputably, many mathematicians have good minds. There is, surely, nothing to hinder the happening of such a thing. But some mathematicians are so impressively dull when they stray from the confines of their specific field of interest that one hesitates to generalize. The striking disagreement between the theoretically assumed and the actually achieved effects of the study of this, that and the other subject seems, however, so far as pedagogical thinking goes, never to disturb the deliberation that goes on in our curriculum dispensaries. The truth of the matter is that we have no means of evaluating the *effects* of our instruction. We measure and grade the *stuff*, the *content* which has managed to survive in the minds of our students at the time of our periodic probings. The *effects* are taken for granted.

Hope "springs eternal" that the youth of to-morrow will see things a bit more clearly than we of to-day are seeing them. That they are having glimmerings of insight may be inferred from the following personal experience. A laboratory chum in a moment of frank confession remarked: "If I thought that I should ever turn out to be like Professor Blank I should now go out and soak my head in gasoline." Why he preferred that particular method of procedure he did not stop to explain. He was taking Professor Blank's subject, and no doubt Professor Blank, after the usual fashion, was quite convinced of the wholesome effects to be expected from the study of his subject. But if our curriculum formula of education were valid, if the study of the various subjects taught by the various Professors Blank, and if the requirements for graduation were as rigid as in former years, the price of gasoline would probably go up in the neighborhood of some of our colleges, provided this were the only means of exit under academic provocations.

Many educators are now being heard to say that probably fifty per cent. of the students in many colleges are failing to take advantage of their opportunities, and would be better off elsewhere. We seem to accept this high death-rate with about the same fatalism as that with which we once accepted plagues and pestilences. Among the casualties in education as in war must be included, of course, not merely those who are killed, but also those who are wounded, gassed or otherwise disabled for the battle of life. There are many who complete their

education according to the stipulated conditions and hence are not to be numbered among the dead, but who, while they have "picked up wit as pigeons peas" and have dealt it out again as the instructor "doth please," have not risen above the mass either in intellectual tastes or social consciousness. From among the latter type come all too many candidates for the high and honorable calling of college teaching.

The remedy for our present educational miscarriage (thinking again of the Trobrianders, our comrades in ignorance) does not, in spite of claims to the contrary, consist of a return to the curriculum systems of the past, nor will it be found in the reorganization and perfection of the curricula of the present. It is, in short, not a matter of curriculum. While it seems indisputable that education is accomplished only through impacts between personalities, it is idle to fancy that we may retrieve ourselves by attempting to restore by force of arms the "passing" college professor to his quondam position of authority and influence. The ancient curriculum and the bygone professor, we must remember, functioned in an ancient setting. Between the curriculum, the professor and the setting, the setting is the all-important thing. If the professor with his personality is gone; if in the colleges as in society in general "the individual withers and the world is more and more," it still remains true that institutions may have personalities. Guided only by our empirical thinking we have noted for ages the educational effectiveness of institutions that possess what we call "atmosphere." But how to go about producing this indispensable agency is not a subject on which our curriculum committees spend any of their time. They are occupied with hours of credit, units for graduation; in short, about ingredients, formulae, prescriptions. Most of our administrators, captivated as they are by American ideals of bigness, are leading us toward depersonalization, disintegration, elephantiasis. To have atmosphere, to be able to educate effectively, our institutions must be unified, integrated, be-souled. How this can be done is another story.

HEREDITY CONCEPTS OF THE ANCIENT HINDUS

By Dr. FREDERICK S. HAMMETT

THE RESEARCH INSTITUTE OF THE LANKENAU HOSPITAL, PHILADELPHIA

For some years past I have been extricating from the Müller literal translations of "The Sacred Books of the East" the statements concerned with biological matters. This was done with the intention of at some time collecting them together into a book as a contribution to the historical development of our present state of biological knowledge. Due to the press of activities in other directions, however, this bibliophilic diversion seems in a fair way to end otherwise than by first intention. Certain references in Raymond Pearl's recent pamphlet on "The Present Status of Eugenics" relative to man's early concepts of heredity stimulated memories of explicit statements of the ancient Hindu writers. Therefore, there was nothing to do but to cull them out and set them forth for the pleasure of those who admire the past.

A word as to the source of the material. The quotations are direct transcriptions from the literal translation of classical ancient Hindu manuscripts made by competent scholars and edited by Müller. Correspondence with American scholars has established the fact that the series is the standard for students in this field, and that the authenticity is unquestioned. Although the exact age of the writing of the originals is unknown, it is known that they had their beginnings several centuries antecedent to the Christian era, that the earlier ones were developed prior to the rise of Grecian civilization and the later ones independently thereof.

Though I would spare the reader as much mental effort as possible, the nature of the material makes impossible its presentation in flowing, easy style. A certain apparent disjointedness is inescapable. These ancient scientists were, pleasingly or not, according to the point of view, addicted to putting down their conclusions in sharp, concise phrases. The absolute necessity for this is evident. Ink and paper were not plentiful, reproduction was tedious and time-consuming, and editors were presumably unlenient, not apparently so as they are now. The exigencies demanded condensation, and this was accomplished with marvelous clarity. As a result each phrase, the crystallized conclusion from thoughtful observation, becomes a nucleus of intellectual appreciation for the biological connoisseur and a shining example for the recorder of scientific work of to-day.

Let us now turn to the records themselves. The principle of straight-line descent was not only recognized by the ancient Hindu scientists, but was stressed in some completeness. See what they taught.

"The same seed which is laid is brought forth."[1] "The seed infused into the womb is fashioned. . . For whatlike the seed is fashioned in the womb, suchlike it is born."[2] "The animal becomes manifest to its own form, cow to cow, horse to horse, and man to man."[3] "On comparing the seed and the receptacle (of the seed), the seed is declared to be more important, for the offspring of all created beings is marked by the characteristics

[1] "Satapatha Brahmana," vol. 41, 6, 1, 3, 20; volume numbers in all references refer to Müller's series of "The Sacred Books of the East," Oxford Press.

[2] *Ibid.*, 6, 7, 2, 5: 7.

[3] *Ibid.*, 6, 3, 1, 22.

of the seed. Whatever (kind of) seed is sown in a field, prepared in due season, (a plant of) that same kind, marked with the peculiar qualities of the seed springs up in it. This earth, indeed, is called the primeval womb of created beings; but the seed develops not in its development any properties of the womb. In this world seeds of different kinds, sown at the proper time in the land, even in one field, come forth (each) according to its kind.—That one (plant) should be sown and another be produced cannot happen; whatever seed is sown (a plant of) that kind comes forth."[4] "They yield their products, each according to its own faculty, reach, and particular nature of the germ . . ."[5] "It is from the remote end downwards that a race is propagated."[6] "Wherefore one is born, suchlike he becomes."[7]

These biological facts undoubtedly participated in the development of the idea of immortality through germplasm continuity. This principle, commonly attributed to Weismann, or as a logical conclusion to be drawn therefrom, had its inception ages before this biologist appeared upon the stage. The name of its originator is unknown. It is none the less significant that the idea was current in the earliest stages of natural science development. Read what was taught:

"Seed is . . . infused into the descendants, and by that infused seed descendants are generated again and again."[8] "The seed which is infused into the womb becomes generative."[9] "Now it can also be perceived by the senses that the (father) has been reproduced separately (in the son); for the likeness . . . is even visible, only (their) bodies are different."[10] "In thy offspring thou art born again, that, mortal, is thy immortality."[11] "Undecaying and immortal is this (earth), and undecaying and immortal is the vital energy (sperm)."[12] "The generative power is immortal."[13]

[4] "The Laws of Manu," vol. 25, 9, 35–40.
[5] "Saddharma Pundarika," vol. 21, 5, 15.
[6] "Satapatha Brahmana," vol. 12, 1, 4, 2, 4.
[7] *Ibid.*, vol. 41, 7, 4, 1, 1.
[8] *Ibid.*, vol. 12, 1, 5, 3, 16.
[9] *Ibid.*, vol. 41, 7, 3, 1, 28.
[10] "Apastamba (Sacred Laws)," vol. 2, 2, 9, 24, 2.
[11] *Ibid.*, vol. 2, 9, 24, 1.
[12] "Satapatha Brahmana," vol. 26, 2, 3, 1.
[13] *Ibid.*, vol. 41, 7, 3, 1, 46.

It is not impossible that early recognition of the principle stated above lies at the root of the development of the caste system of India. It is written that "a base born man either resembles in character his father, or his mother, or both; he can never conceal his real nature."[14] The natural reaction to such observation in the field of heredity would be the segregation of the base-born into classes with which the non-base-born should not intermingle for fear the base traits might be passed on and thus contaminate the descendents.

The idea that certain diseases are inherited is mentioned in more places than one and specifically intimated in the statement that a man might be ill "in consequence of a sin committed by (thy) father or by (thy) mother."[15] These theoretical concepts derived from close observation were put to practical use in the directions given for choosing a mate. Thus the admonishment:

. . . in connecting himself with a wife, let him carefully avoid the ten following families, be they ever so rich in kine, horses, sheep, grain or (other property): (Viz.) one which neglects the sacred rites, one in which no male children (are born), one in which the Veda is not studied, one (the members of) which have thick hair on the body, those which are subject to hemorrhoids, phthisis, weakness of digestion, epilepsy, or white and black leprosy. Let him not marry a maiden (with) reddish (hair), nor one who has a redundant member, nor one who is sickly, nor one with either no hair (on the body) or too much, nor one who is garrulous or has red (eyes). Let him wed a female free from bodily defects—a moderate (quantity of) hair on the body and on the head, small teeth and soft limbs.[16]

In another place similar directions are given with the additional command which indicates a knowledge of the possible harm to be derived from inbreeding. It is written:

Nor (should he marry) one descended from his maternal ancestors within the fifth, or from

[14] "The Laws of Manu," vol. 25, 10, 59.
[15] "Hymns of the Arthava Veda," vol. 42, 2, 5, 30, 4.
[16] "The Laws of Manu," vol. 25, 3, 6–10.

his paternal ancestors within the seventh degree. . . Nor one diseased. Nor one with a limb too much. Nor one with a limb too little. Nor one whose hair is decidedly red.[17]

It would be interesting to know the basis of the antipathy to persons of red hair. Perhaps it lay in a belief which exists even to-day that such were commonly termagants and hence unsuited to be wives of males demanding complete submission, a characteristic not entirely Hindu in its nature.

In a race in which the idea of male dominance was and still is so prominent, it is not surprising that sex determination was a matter of great interest. The not too oldish modern idea of some biologists that a male child is the result of a male germ was anticipated some thousands of years ago. Even our chromosomologists must admit that the statement—"Into thy womb shall enter a male germ, as an arrow into a quiver! May a man be born there, a son, ten months old!"[18] is not unprophetic.

Specific ceremonies were necessary for the begetting of a child of either sex. To the psychologist the symbolism in these is at once apparent. The ceremony for the male "must be performed before the embryo begins to move."[19] To get a male child the husband must give to the wife during the third month of her pregnancy, "after she has fasted, in curds from a cow which has a calf of the same color (with herself), two beans and one barley grain for each handful of curds. To his question 'What dost thou drink? What dost thou drink?' she should thrice reply, 'Generation of a male child! Generation of a male child!' Thus three handfuls (of curds). He then inserts into her right nostril, in the shadow of a round apartment, (the sap of) an herb which is not faded."[20] Other details leading to the same end are devised. The husband "should seize her thumb if he desires that only male children may be born to him. Her other fingers (if he is) desirous of female (children)." He should seize "the hand on the hair side together with the thumb, (if) desirous of both (male and female children)."[21] "He shall seize the hand of a girl. Who should possess (the auspicious) characteristics required. Whose limbs shall be proportionate. Whose hair should be smooth. Who should also have at her neck two curls turned to the right. (Of such a girl) he shall know that she will give birth to six men."[22]

Over and above these symbolistic appurtenances of sex determination the ancient Hindus advocated dietary regulations to bring about the desired end, much as do certain food faddists of to-day. See if these thirty-century-old rules should be any less efficacious than those promulgated in these times of ultra-civilization.

If a man wishes that a white son should be born to him . . . then, after having prepared boiled rice with milk and butter, they should both (man and wife) eat, being fit to have offspring. And if a man wishes that a reddish son with tawney eyes should be born to him . . . then, after having prepared boiled rice with coagulated milk and butter, they should both eat, being fit to have offspring. And if a man wishes that a dark son should be born to him with red eyes . . . then, after having prepared boiled rice with water and butter, they should both eat, being fit to have offspring. And if a man wishes that a learned daughter should be born to him . . . then, after having prepared boiled rice with sesamum and butter, they should both eat, being fit to have offspring. And if a man wishes that a learned son should be born to him . . . then, after having prepared boiled rice with meat and butter, they should both eat, being fit to have offspring.[23]

[17] "The Institutes of Vishnu," vol. 7, 24, 10–15.

[18] "Hymns of the Arthava Veda," vol. 42, 4, 3, 23, 2.

[19] "Sankayana Grihya Sutra," vol. 29, 1, 20: "The Institutes of Vishnu," vol. 7, 26, 2.

[20] "Asvakayana Grihya Sutra," vol. 29, 1, 13, 2–5.

[21] *Ibid.*, 1, 7, 3–5.

[22] "Sankayana Grihya Sutra," vol. 29, 1, 5, 5–10.

[23] "Brihadaranya Upanishad," vol. 15, 6, 4, 14–18.

It is hardly necessary to expatiate on these data. They are self-explanatory, and any attempt to adorn them would be presumptuous. I can not resist suggesting, however, that in view of this evidence of early biological wisdom we should look carefully to our laurels in order to be sure that they are not indurated with the dust of the ages.

THE PREHISTORY OF TELEVISION

By Dr. BERTHOLD LAUFER

CURATOR OF ANTHROPOLOGY, FIELD MUSEUM OF NATURAL HISTORY, CHICAGO

In his drama "Back to Methuselah" George Bernard Shaw depicts the following scene as a reality in the year 2170: the head of the British government is holding a conference with his cabinet ministers, who are several hundred miles distant, in this manner—that he operates a switchboard near his desk and, by pressing a certain key, makes appear on a silver screen a life-size picture of the person to whom he desires to talk and whose voice is simultaneously transmitted.

In April, 1927, the Bell Telephone Laboratories gave the first practical demonstration of transmitting over electric wires the pictures and voices of moving persons, voice and image being perfectly synchronized. A two-way telephonic communication was maintained between Washington and New York. Secretary Hoover in Washington opened the demonstration, and the illuminated image of himself cast over the wire on a screen in New York synchronized perfectly with his voice that was heard over the telephone at the same time. One telephone line was used for transmitting the voice, another for transmitting the television current and a third for synchronizing the electric driving-motors at each end of the lines. It has since been demonstrated that both the voice and the "picture" currents can be sent over the same wire or, in the case of radio transmission, over the same wave-length.

While television at present is a fact, it has been the dream of mankind for hundreds and thousands of years. In my monograph, "The Prehistory of Aviation," recently published by Field Museum, Chicago, I have emphasized the fact that human imagination has been of paramount importance and proved most fertile in the development of mechanics and inventions and that the trend of man's mind toward the romantic and adventurous has resulted in the conquest of the air. The essential point is that many fundamental contrivances have not been reasoned out logically through progressive scientific thought, but that man's mind conceived them through visionary reveries as an accomplished fact and then proceeded to work toward this imaginary goal. Thus television also has its prehistory in the domain of oriental folk-lore, a brief outline of which is given on the following pages.

In Firdausi's great epic poem, the Shāhnāmeh ("Book of Kings"), figures a cup which mirrors the world and distant persons. It is the property of King Kai Khosrau and appears in the love-story of Bizhan and Manizha. The king, while holding a feast, receives a petition for succor from the people of Irmān, whose country is being ravaged by wild boars, and sends Bizhan and Gurgin to scour the country of them. Through the machinations of Gurgin, who envies him, Bizhan falls in love with Afrasiyab's

daughter, Manizha, who carries Bizhan off to Turan and hides him in her palace. He is discovered and imprisoned in a pit with Manizha as his attendant. In the meantime Gurgin has returned to Iran, where his lame story rouses suspicion. By means of the divining-cup Kai Khosrau ascertains Bizhan's situation and dispatches the hero Rustam to deliver him. The king says to Giv, Bizhan's afflicted father (in Warner's translation):

Then will I
Call for the cup that mirroreth the world,
And stand before God's presence. In that cup
I shall behold the seven climes of earth,
Both field and fell and all the provinces,
Will offer reverence to mine ancestors,
My chosen, gracious lords, and thou shalt know
Where thy son is. The cup will show me all.

Then the poet narrates how Kai Khosrau saw Bizhan in the cup that shows the world:

When jocund New Year's Day arrived, Giv yearned
For consultation with that glorious cup,
And came, bent double on his son's account
But hopeful, to Khosrau who, seeing him
With shrunken cheeks and sorely stricken heart,
Went and arrayed himself in Ruman garb
To seek God's presence. Then before the Maker
He cried and oft-times blessed the Shining One,
Imploring of the Succorer succor, strength,
And justice on pernicious Ahriman,
And then returning to his throne, assumed
The Kaian crown, took up the cup, and gazed.
He saw the seven climes reflected there,
And every act and presage of high heaven,
Their fashion, cast, and scope, made manifest.
From Aries to Pisces he beheld
All mirrored in it—Saturn, Jupiter,
Mars, Leo, Sol and Luna, Mercury,
And Venus. In that cup the wizard-king
Was wont to see futurity. He scanned
The seven climes for traces of Bizhan,
And, when he reached the Kargasars, beheld him
By God's decree fast fettered in the pit,
And praying in his misery for death,
With one, the daughter of a royal race,
Attending him. The Shah, with smiles that lighted
The daïs, turned his face to Giv and said,—
"Bizhan is yet alive; be of good cheer!"

In one of the stories of the Arabian Nights (No. 271) the three sons of a Sultan of India—Prince Husain, Prince Ali and Prince Ahmed—undertake a year's journey into a distant part of the world to find some unusual treasure for their royal father, who had promised the hand of a princess to him who would bring back the rarest jewel. Prince Ali traveled to Shiras, capital of Iran, and while rambling in the bazar of the city, one day met a man who carried in his hand an ivory tube about a yard long and offered it for sale at the price of thirty thousand sequins. The prince thought him to be a fool, as he demanded so enormous a sum for such a wretched thing, but was soon informed that this broker was wiser and more sensible than all others of his profession. He examined the ivory telescope, which was equipped with a piece of glass at either end and which if placed in front of the eye brought anything close to it, even though it may have been many hundreds of miles away. Moreover, this tube had the miraculous power of showing any object or any person its owner desired to see. Prince Ali wished to see his father whom he had left in India, and no sooner did he hold the ivory tube close to his eye than he espied him hale and hearty seated on his throne and giving judgment to the people of his land. Then he demanded to behold his beloved princess, and immediately he caught sight of her as she was leisurely reclining on a couch, chatting and laughing and attended by a flock of maids.

In Grimm's tale, "The Four Skilful Brothers," the situation is very similar to that of the preceding story. Four brothers go out into the world to earn their living and to learn a craft. One becomes an expert thief. The second meets a man who asks him what he wishes to learn in the world. "I do not know it yet," he replies. "Come along with me and become a star-gazer; there

is nothing better than that, nothing will be hidden to one." He consented and became so clever a star-gazer that his master, when the boy had finished his apprenticeship and would leave him, presented him with a telescope and said, "This will enable you to see what occurs on earth and in heaven, and nothing will remain concealed to you." He meets with his three brothers, who have also acquired an extraordinary art, and soon there is an opportunity for them to put their knowledge to the test. The king's daughter was kidnapped by a dragon, and the king made it known that he who would bring her back should receive her as his consort. The four brothers decide to deliver her from the dragon. "I shall soon know where she is," said the star-gazer, looked through his telescope and announced, "I behold her, she is seated far away on a rock in the sea and beside her the dragon who guards her." Then he went to see the king and requested a ship for himself and his brothers, and crossed with them the sea till they arrived at the rock. They return with the king's daughter, and naturally engaged in a quarrel as to which should have her as his wife. The star-gazer said, "If I had not espied her, all your arts would have been futile; therefore she is mine." As all their claims were of equal merits, the king decided that no one should get her, but assigned to each a half kingdom as his reward.

Lucian, in his "True History" (I, 26), relates that in the palace of Endymion, king of the moon, he saw a large mirror placed above a well of mediocre depth. In descending into this well, it was possible to hear whatever was talked on earth; and in lifting one's eyes toward the mirror, one saw all towns and all nations as though one were in their midst. "I saw there my parents and my country," he adds, "I do not know whether they saw me too. I do not venture to affirm it, but he who declines to believe me might go to the moon, and will then convince himself that I am not an impostor."

Zosimus, an alchemist who lived in Egypt during the third and fourth centuries A.D., discusses the electron, an alloy of gold and silver, and mentions a magic mirror which Alexander the Great had made of it and which subsequently was exhibited in the Temple of the Seven Gates (corresponding to the seven heavens) above all spheres. In this mirror one beheld one's own future and destiny until one's death. This was a divine mirror symbolizing God (compare Epistle of James, I, 23–24; I Corinthians XIII, 12; II Corinthians III, 18).

In 331 B.C. Alexander the Great founded the city named for him—Alexandria. About 280 B.C. the famed Pharus was constructed there by Sostratus of Cnidus—the earliest lighthouse known in history. It was about three hundred feet high, a three-storied structure; the lower story was square, the middle one octagonal, the upper one, which contained the light, circular and surmounted by a colossal statue of Poseidon (Neptune). The Pharus of Alexandria became widely known in the Islamic world, but Mohammedan authors erroneously attribute its foundation to the great world-conqueror himself, designating it Menarat Iskanderiah ("Lighthouse of Alexander"). They describe it as one of the marvels of the world. On the top of this lighthouse, they say, Alexander placed a magic mirror in which could be sighted all incoming ships, the country Rum (the Byzantine empire), the islands of the sea and whatever was done by the inhabitants. By virtue of this mirror, as long as it existed, the city of Alexandria was said to preserve its grandeur and power. The Persians called this lighthouse Mirror of Alexander (Aineh Iskenderi), believing that the fortunes of Alexandria depended on it, as it was a talisman con-

structed under the influence of a certain constellation. It is said to have broken to pieces shortly before the city was conquered by the Arabs in A.D. 641.

Rabbi Benjamin of Tudela, who traveled in the Orient between the years 1159 and 1173, mentions the high tower of Alexandria surmounted by a glass mirror by means of which the approach of a ship or a hostile fleet could be noticed even when it was a twenty days' voyage off. The city was therefore prepared for the reception of a hostile ship from whatever direction she approached. Once, however, when Greece was still subject to the Alexandrians, Benjamin continues, a Greek vessel cast anchor in the port of Alexandria. The captain, a Greek, Theodorus by name, instructed in all sciences, brought to the Egyptian king valuable presents of gold and silver, silk and purple. His ship was at anchor opposite the lighthouse. Every day the captain invited the guard of the lighthouse with his servants on board his ship until they were on friendly terms. One day he treated them to an opulent feast and filled them with wine till they were intoxicated and fell into a deep slumber. The captain then ordered his crew to smash the mirror, and set sail the same night. From that time onward Christian ships, small prowlers as well as large vessels, entered the port, and snatched away two large islands, Crete and Cyprus, which are still under Christian rule. Egypt was henceforward unable to resist the Greek power.

Leo Africanus, in his "History of Africa," writes that the mirror of Alexandria was of "steel glass" by the hidden virtue of which passing ships, while the glass was uncovered, should immediately be set on fire; but when the glass was broken by the Mohammedans, its secret virtue vanished.

The fame of Alexandria's Pharus and television mirror even spread to the Far East. Chao Ju-Kwa, who was stationed as inspector of maritime trade at the port of Ts'üan-chou in Fu-kien and collected there from the lips of foreign traders much interesting information on the countries of the Indian Ocean, which he published in his "Chu fan chi," written in A.D. 1225, gives a brief notice of Alexandria and its lighthouse. "On the summit of it," he writes, "there was a wondrous large mirror. In the event of a surprise attack by foreign warships they would be detected beforehand by this mirror, and the troops on guard duty were ready to meet the situation. In recent years Alexandria was visited by a foreigner who asked for work in the guardhouse of the tower and who was employed as a janitor. He was not suspected for years, when suddenly he seized an opportunity of abstracting the mirror and flung it into the sea, whereupon he disappeared." A late Chinese cyclopedia (*San ts'ai t'u hui*) has disfigured this tradition considerably by stating that Tsu-ko-ni (Alexander) erected in Egypt a temple on the top of which there was a mirror which when pirates of other countries made a raid reflected them and thus announced their arrival.

In the famous letter of Prester John (71) purporting to have been written by him to the Byzantine emperor, Manuel (1143–80), is described a marvelous mirror which is reached by ascending a hundred and twenty-five steps over an elaborate structure of pillars. In this mirror all plots and machinations and everything that was done in the adjacent and subjected provinces either on behalf of Prester John or against him would be clearly revealed and recognized; day and night it was guarded by twelve thousand armed men that it might not be broken by an accident. In the work of Johannes Witte de Hese (1389) this mirror of Prester John is also mentioned: three precious stones are deposited in it; one of these

directs and sharpens the vision; another, the senses; the third, experience; three very capable doctors have been elected to examine the mirror and see in it everything that is done in the world.

A "History of the World" published in Neo-Greek by Dorotheos, metropolitan of Malvasia, at Venice in 1763, alludes to a magic mirror in the imperial palace of Constantinople made by the emperor Leo the Philosopher: whatever existed or happened or was intended to be done in the world could be most clearly visualized in this mirror. The Emperor Michael, who was given to a voluptuous life, was informed one day by a messenger that he had beheld in the mirror the war preparations of the Turks against Constantinople. Michael, who just pampered at a banquet, did not like to be disturbed and ordered a servant to smash the mirror to atoms.

According to an Arabic tradition, Saurid was the wealthiest king on earth and had a mirror made from various alloys, wherein he could scan whatever occurred in the seven zones, whether good or bad, and what land was irrigated or not. This mirror was placed in the city of Amsus on the top of a green marble column. In the city of Sa on the bank of the Nile stood a pillar of white marble and upon it a mirror in which King Sa, for whom the city was named, was able to discern whatever happened in the seven zones.

Spencer, in his "Fairy Queen," has Merlin make a magic mirror in which a girl beholds the image of her swain. Walter Scott, in his "Lay of the Last Minstrel," relates that Cornelius Agrippa showed the Count of Surrey, during his sojourn in Italy, his sweetheart Geraldine in a mirror as she was reclining on a couch and reading her lover's poems by the light of a wax candle.

Nathaniel Hawthorne, in his story "Dr. Heidegger's Experiment," refers to a looking-glass hung in the doctor's room, "presenting its high and dusty plate within a tarnished gilt frame. Among many wonderful stories related of this mirror, it was fabled that the spirits of all the doctor's deceased patients dwelt within its verge, and would stare him in the face whenever he looked thitherward."

A SUBSTITUTE FOR ARSENIC

By S. MARCOVITCH

TENNESSEE AGRICULTURAL EXPERIMENT STATION

DON MARQUIS in his book "Archie and Mehitabel" puts the following words in the mouth of Archie the cockroach:

i am going to start
a revolution
i saw a kitchen
worker killing
water bugs with poison
hunting pretty
little roaches
down to death
it set my blood to
boiling
i thought of all
the massacres and slaughter
of persecuted insects
at the hands of cruel humans
and i cried
aloud to heaven
and i knelt
on all six legs
and vowed a vow
of vengence
i shall organize the insects
i shall drill them
i shall lead them
i shall fling a billion
times a billion billion

. . . . . .
come o mosquitoes
a billion billion strong
and sting a billion baldheads
till they butt against each other
and break like eggshells
. . . . . .
curses on the species
that invented roach poison

Evidently Archie and his cohorts are rebelling at chemical warfare, so that we humans may be assured that we have at least aroused fear in the hearts of our foes.

Without minimizing the importance of biological phenomena—as, for example, parasitism; the climatic checks of temperature and humidity, or cultural methods, such as time of planting and rotation of crops—we must place our main reliance in chemicals for keeping in subjection at least 80 per cent. of the insect pests.

The use of insecticides was stimulated by the appearance of the Colorado potato beetle in 1869, when the familiar Paris green came into vogue as a protective agent for phytophagous insects. The entire science of spraying and dusting of plants is, therefore, a development of the past forty or fifty years; and the last decade has witnessed a greater development of insecticides than all previous time. This has resulted in the creation of new chemical industries, such as the manufacture of calcium arsenate.

No sooner had the farmer been schooled in the use of calcium arsenate for protecting his cotton against the ravages of the boll weevil than a severe infestation (in 1923) made an unprecedented demand for calcium arsenate. All available stocks of calcium arsenate were soon exhausted. Prior to 1923 we were concerned in educating the farmer to dust his cotton, but now a new menace loomed on the horizon—a lack of poison. Well might our six-footed enemy rejoice over our lack of ammunition.

The price of arsenic doubled, or trebled. Mining engineers began scouting for new sources of arsenic. Much was written about the arsenic problem, the arsenic situation, the arsenic shortage and the manufacture of calcium arsenate. We were led into this dilemma because arsenic was the only stomach poison known that could be used as an insecticide. The need for a substitute was evident. The importance of the cotton crop, the increasing number of crop pests and the limited production of arsenic make it imperative that we have at least one other weapon by which to subdue the ravenous enemy. Our new weapon is sodium fluosilicate—first used in 1924 at the Tennessee Experiment Station for combating the Mexican bean beetle.

Exhaustive research work by the Chemical Warfare Service in 1926 and 1927 also demonstrated that sodium fluosilicate is more effective than calcium arsenate against the cotton boll weevil. These results led a prominent entomologist to remark, "We need have no fear that there is going to be any difficulty due to a scarcity of calcium arsenate. That bogey is gone and gone for good."

Comparative Toxicity Studies

As we all know, arsenic is a deadly poison to human beings, and this fact suggested its use as an insecticide. The next question was: What is the toxicity of sodium fluosilicate as compared with arsenic, to the lower as well as the higher forms of life? To determine this point, a series of experiments were initiated with mosquitoes, representing the invertebrates, and with rabbits, representing the vertebrates. Mosquito larvae proved especially well adapted for the purpose, since they are abundant, easily obtained or bred and live in a medium which lends itself readily to chemical changes of any desired concentration. Death of the larvae takes place

primarily by the oral ingestion of the chemical.

Sodium fluosilicate .01 molar (1–532) produced 50 per cent. mortality of the larvae of *Culex quinquefasciatus* within fifty-five minutes, whereas at the same concentration sodium arsenite required 135 minutes, sodium arsenate 390 minutes, and sodium fluoride 420 minutes. When the above chemicals were used against the grasshopper, *Melanoplus femur-rubrum*, in poison baits, sodium arsenite produced 89 per cent. mortality within forty-eight hours, whereas sodium fluosilicate gave 100 per cent. Similar results were secured with the cutworm, *Feltia ducens*. Poison baits with sodium fluosilicate were found to be distasteful to chickens. This is of considerable advantage when baits have to be used in the proximity of poultry or game birds.

The fluorine compounds were also studied on organisms lower than insects. With *Lumbricus terrestris*, sodium fluosilicate, sodium fluoride and sodium arsenite, in concentrations of 1–1000, required, respectively, 20, 40 and 240 minutes to produce a lethal effect. For protozoa, *Paramoecium caudatum* was used. A solution of sodium fluosilicate 1–10,000 is fatal almost instantaneously; sodium fluoride 1–1000 produced a kill within sixty minutes; whereas sodium arsenite seemed to be non-toxic. Similar results were secured with *Euglena viridis*.

The high toxicity of fluorine compounds for protozoa would suggest their usefulness against pathogenic forms. For this purpose one would have to use organic fluorides, the chemistry of which is but little known.

After the experimental work had shown that the fluosilicates were more toxic than the arsenicals to many of the lower organisms the next consideration was their relative toxicities to man and the higher animals.

The more extended use of fluosilicates as dusts on plants raises the question of the effects on human health when small quantities are ingested over a prolonged period, as well as the poisonous nature of a single large accidental dose. With rabbits, the minimum fatal dose of sodium fluoride by mouth was found to be 500 mg per kg, and for sodium fluosilicate 120 mg per kg. For comparison with arsenic, the soluble potassium arsenite required 14 mg per kg. To estimate the effect on man, we find that the minimum lethal dose would be thirty grams of sodium fluoride, 7.2 grams of sodium fluosilicate and .84 of a gram of potassium arsenite. Potassium arsenite is therefore about nine times as toxic to man as sodium fluosilicate and thirty times as toxic as sodium fluoride.

The cumulative and fatal action of very small doses of arsenic is well known. The evidence from various sources indicates that fluorine compounds in small daily doses may be administered over an extended period of time without fatal results. This aspect of the subject is of importance at the present time because the small arsenical residue found on apples is considered objectionable by various agencies. Apple growers are therefore demanding a substitute for lead arsenate to be used as a spray for the codling moth. Since sodium fluosilicate is acid and slightly soluble it is not compatible with the fungicides now in use, and can not as yet replace lead arsenate. Efforts are being made, however, to devise a fluorine spray material that will be safe on foliage and toxic to insects.

How Fluorine Compounds Kill Insects

Most insects are so greedy that they do not hesitate to swallow arsenic on foliage. In recent years we have found many other insects that do not succumb to the foliage dusted or sprayed with an

arsenical. These are more dainty in their dietary habits and refuse to eat other than clean foliage. This is known as the repellent effect of arsenic on such insects as the Japanese beetle, blister beetles, cucumber beetles and flea beetles.

Professor Baerg, of the Arkansas Experiment Station, as well as Mr. Ingram, of the United States Bureau of Entomology, has found that blister beetles may be killed by sodium fluosilicate. To quote from Mr. Ingram's report:

> Calcium arsenate, Paris green and lead arsenate have been tried as dusts and as sprays at varying strengths, but in all cases these merely drove the beetles away, which would not eat the poisoned leaves. Sodium fluosilicate has proved to be the best remedy. The beetles die, not from eating the poisoned foliage, but from getting the poison on their feet and then raking their feet through the mouth to get the irritating stuff off.

G. D. Schafer was the first to discover the irritating properties of sodium fluoride on roaches. Those insects that have the "cleaning-up" habit are very easily fooled into taking the powdered fluorides into their mouths. For this reason dry dusts are more effective than sprays, since the latter form a varnish-like coating.

After the fluorine is absorbed by the insect, the precipitation of essential calcium from the tissues is effected. The meager calcium content of the lower organisms may account for their easy susceptibility to fluorine compounds.

Source of Sodium Fluosilicate

It is of interest to note that sodium fluosilicate is made from phosphate rock, the same material which also furnishes us with fertilizer. Phosphate rock contains about 3 per cent. calcium fluoride and some silica. When sulphuric acid is added to phosphate rock for the purpose of making acid phosphate, fumes are liberated. Formerly these fumes were allowed to escape, but as they were very injurious to vegetation, laws were enacted requiring that the gases be confined. The silicon tetrafluoride gases are now conducted into towers with dripping water, forming fluosilicic acid. In most cases this acid is not saved, but is allowed to drain away. When sodium chloride is added to fluosilicic acid, sodium fluosilicate precipitates out. As there are no extensive uses for by-product fluosilicic acid, probably 95 per cent. is discarded. The commercial sodium fluosilicate is dense and not particularly adapted for dusting. A light, fluffy sodium fluosilicate is now being manufactured more suitable for dusting operations on plants.

As the manufacture of sodium fluosilicate becomes standardized, and its uses become better known, every farm home and even the city dweller will have a supply of sodium fluosilicate. When Archie has a vision of our entire human population thus prepared to annihilate the race of the six-footed, no doubt he will throw down his arms, raise the flag of truce and surrender, as he might well do.

RABBIT FEVER OR TULAREMIA

By WILL C. BARNES

On Thanksgiving Day, 1927, a United States naval surgeon, well known in medical and social circles in the city of Washington, accompanied by his brother, visited the family farm in central Virginia for a holiday rabbit hunt. Rabbits were fairly plentiful and the two men had several very successful days' sport.

Soon after his return to Washington the naval officer went to the U. S. Naval Hospital suffering from severe headaches accompanied by a high temperature and chills, with terrific pains in every part of his body. Also, the glands in his arm pits were greatly enlarged and very sore. In spite of all that medical science could do he died within fifteen days.

Meantime the brother, suffering from the same symptoms, had been taken to a hospital in Charlottesville, Virginia, where he was a very sick man for several weeks but eventually recovered.

The sickness was diagnosed by Naval Hospital surgeons as rabbit fever, or tularemia, a comparatively new disease to the medical fraternity, considered as some form of low fever and treated accordingly.

The death of the naval surgeon, however, attracted wide attention to the trouble, and many persons learned for the first time that there lurked in the body of little old "Peter Rabbit" the germs of a disease for which to date there has been found no cure and from which the death loss is big enough to challenge the best ability of the medical world to discover a remedy.

History of the Disease

The history of the discovery of this new and in many respects mysterious disease is an interesting chapter in medical research.

In 1907 the late Dr. Aneil Martin, of Phoenix, Arizona, had a number of patients who were suffering from some eye trouble quite unlike anything he had ever seen. Down that way trachoma is a very common disease of the eyes, especially among the Indians. Dr. Martin was an expert on that trouble, but his tests for trachoma gave negative results. He found the symptoms very similar to typhoid fever but with ulcers on the eyes and hands. The cases ran for from four to six weeks, one for three months or more. Each gradually recovered. The history of every case showed that the patients had been handling the common western jack-rabbit (*Lepus californicus*). There was at that time, 1907–8, a bounty on jack-rabbits due to their inroads upon the alfalfa fields of the farmers near Phoenix. Farmers were unable to raise any crops at all on a strip several hundred feet wide along the line of the desert. The hungry jacks took every green thing growing. Hence rabbit drives were very common. Thousands of these long-eared speeders were rounded up and driven into pens or corrals like sheep and cattle, there to be killed by clubs. Many of the animals were skinned and used for home consumption and more commonly as food for hogs. For want of a better name for the new-found disease, Dr. Martin called it "rabbit septicemia," caused by a new and at that time undescribed organism.

Pursuing his investigations into this peculiar disease, Dr. Martin wrote to a well-known authority, Dr. Novy, of Ann Arbor, Michigan, describing the cases.

The letter, a copy of which recently came into the author's hands, is in part as follows:

Phoenix, Arizona Territory,
Sept. 19, 1907.

DR. FREDERICK G. NOVY,
ANN ARBOR, MICHIGAN.

Dear Doctor:

There have been during the summer several individuals in this locality who have suffered from an infection as a result of skinning and dressing wild rabbits. They were of the so-called "Jack" variety. Three of these persons have had their primary lesions in or about the eye. Small abscesses formed on the lids and on the bulbar conjunctiva as well.

At the onset there were chills, profuse sweating and an elevation of temperature of from two to five degrees with rapid pulse lasting several days. There were no deaths.

Yours truly,
ANCIL MARTIN.

These cases reported by Dr. Martin are absolutely the first on record for the discovery of this disease in human beings and the organism isolated and studied.

THE NAME TULAREMIA

The scene now changes to Southern California in the year 1910. At that time California was engaged in a war of extermination against the common ground squirrel of the Pacific Coast, believed to harbor and transmit to man bubonic plague by means of fleas found upon the animals. Besides this, their raids upon the farmers' crops were estimated to destroy annually fully twenty million dollars' worth of California farm products. On both counts they were "persona non grata" in the highest degree.

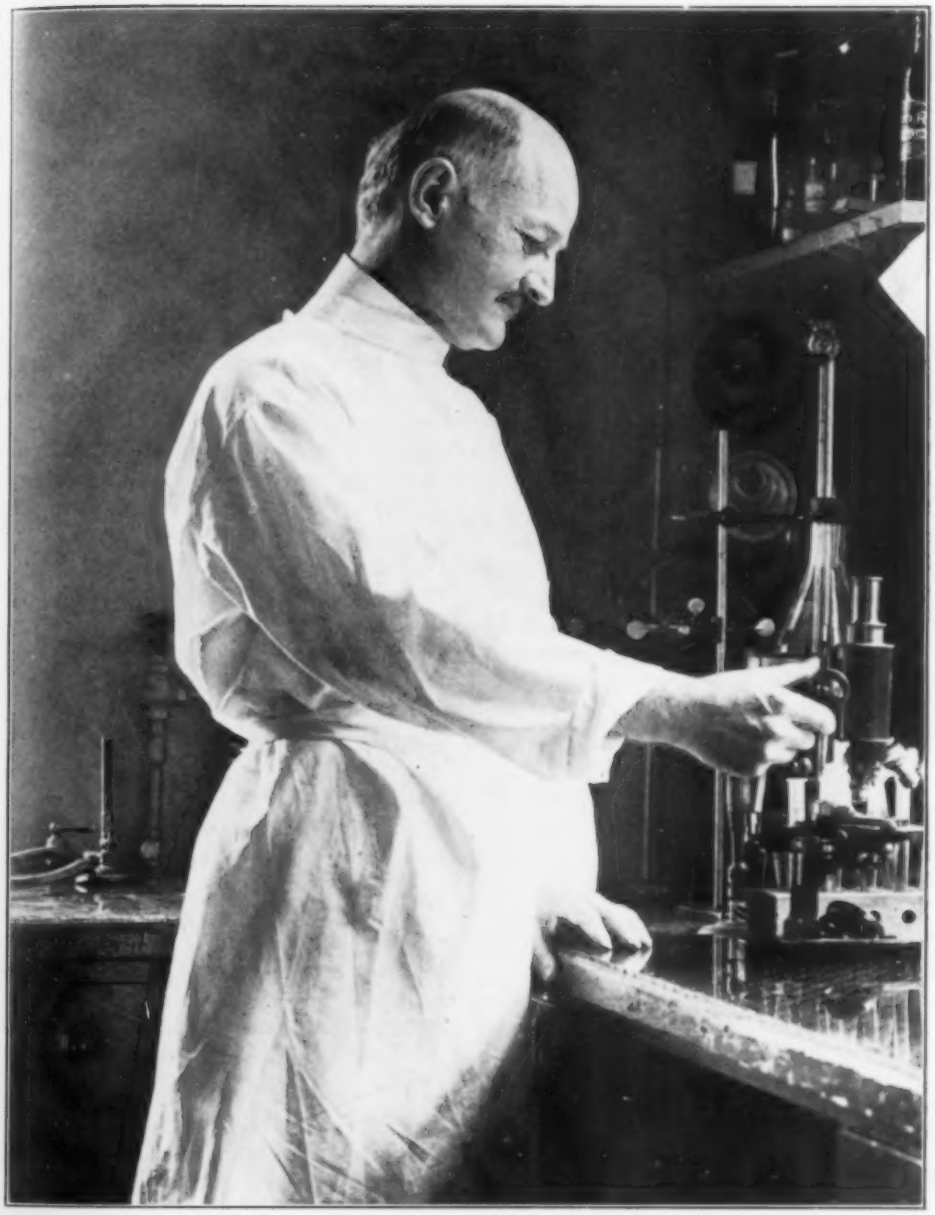
These ground-squirrels were especially numerous in the vicinity of the once great Tulare Lake, in Tulare County, California. In 1910 men at work in that region reported the squirrels to be dying in large numbers from some fatal epidemic. The surgeons of the U. S. Public Health Service who were fighting the ground-squirrels, scenting a possible natural ally in their extermination, sent two Public Health Service surgeons, Drs. G. W. McCoy and C. W. Chapin, post-haste to Southern California to investigate and report on the rodents' misfortunes. These men found the squirrels being decimated rapidly by some, to them unknown, bacterial disease. They worked out its progress through captured squirrels and finally isolated a new causative organism. This they called "Bacterium Tularense" from the fact that the region of greatest infection seemed to be upon the bed of the reclaimed lake which, due to the presence of thousands of acres of the reed or bulrush called "Tules" by the early Spanish settlers, was called "Tule Lake," also the county "Tulare." Hence they coined a brand-new word "Tularense" and fastened it on to this new bacterial pest.

At that time they knew nothing of Dr. Martin's discoveries of several years before. The medical world was not informed of the Arizona cases until some years later.

SHALL IT BE CALLED MARTIN'S DISEASE?

McCoy and Chapin published the results of their investigations early in 1912. Several years later, Dr. Edward Francis, also of the U. S. Public Health Service, looking around for a name for this new peril to the human race, accepted Surgeon McCoy's name and called the disease "Tularemia."

At the meeting of the Arizona State Medical Association, on April 26, 1926, Dr. Martin read a paper on "Tularemia" in which he gave the foregoing history of his cases, dating back to 1907, long before the investigations and discoveries of McCoy and Chapin. He quoted a personal letter from Surgeon Francis written in April, 1925, which said in part, "Your case reported to Dr. Novy in 1907 places you in the position of being the 'Father of Tularemia.'" At a meeting of the Southwestern Medi-



DR. EDWARD FRANCIS

OF THE UNITED STATES PUBLIC HEALTH SERVICE TO WHOM THE AMERICAN MEDICAL ASSOCIATION RECENTLY AWARDED ITS GOLD MEDAL FOR HIS "THOROUGH AND IMPORTANT SCIENTIFIC CONTRIBUTIONS TO THE KNOWLEDGE OF TULAREMIA."

cal Association, held at Dallas, Texas, in 1926, it was proposed to call it "Martin's" disease after the original discoverer of its causative agent in 1907.

The Disease Elsewhere

In 1919 reports came to the Public Health Service in Washington of a new and peculiar disease in the state of Utah known locally as "deer fly fever," "tick fever," etc.

Dr. Francis was sent to Salt Lake to investigate. In southern Utah he found a large number of people suffering from some unknown cause, followed by a number of deaths. The local doctors had been treating the patients for blood poisoning, ulcers, septic infection, typhoid. Nearly all the patients complained of severe pains in the back, swollen glands, terrific headaches. Many had huge repulsive ulcers, generally on their hands, sometimes at other places. No progress whatever had been made in curing the sick ones. Nothing seemed to help.

A review by Francis of a large number of cases proved that the majority of the persons suffering had been handling jack-rabbits previous to their sickness. They were mostly farmers and Indians who had taken part in jack-rabbit drives, then a popular outdoor sport in that region.

From a man suffering from ulcers and other symptoms, Francis took some blood with which he inoculated some guinea-pigs brought with him from Washington.

These at once showed all the symptoms of being infected with Bacterium tularense. Most of them died within a few days after their inoculation. Worst of all, Dr. Francis himself came down with the disease and suffered from all the symptoms he had been observing in others. Leaving further investigations to his assistants, he went back to Washington and into the Naval Hospital a very sick man. Others carried on the Utah studies and determined beyond all doubt that the disease was tularemia and that it was due largely to handling wild rabbits. They tried all sorts of odd experiments, did those surgeons. Many of the Utah sufferers claimed they became infected by the bites of deer flies. They captured a number of these flies and by careful handling caused them to bite a number of captive rabbits and guinea-pigs, that as far as could be determined were perfectly healthy. Within five or six days these bitten rabbits and pigs began to die. Dissection showed every symptom of tularemia.

They reversed their experiments by taking fluid from one of the dead guinea-pigs and placing a few drops of it on various parts of live rabbits. The rabbits began to die in a few days and again dissection showed the presence of the deadly bacilli tularense.

Their research work took the surgeons of the Public Health Service all over the country. In Montana they found a farmer suffering from a bad case of infected eyes. His blood showed bacilli tularense. Then he recalled one day when he was harnessing his horses he picked several large "ticks" from their shoulders. Later he remembered he rubbed his eyes with his fingers. There was no doubt as to the means of his infection and thus a new source of danger was found. Tick fever turned out to be tularemia. Fifteen hundred miles distant, in Cincinnati, Ohio, a Public Health surgeon, Dr. Wherry, found a white butcher and a colored cook suffering from what local physicians had diagnosed as "glanders," a very dangerous communicable disease, generally confined to horses, but occasionally found in humans. He promptly proved it to be tularemia in its worst form. The butcher had handled rabbits in his shop and the cook had dressed them in the kitchen.

The disease is now fairly prevalent in every state of the Union except Wash-

ington, Wisconsin, Delaware, New York and the New England states. It will doubtless eventually be found in all of them. The opinion has been expressed that it is already in them but has not as yet been definitely located and diagnosed.

In 1925, Japanese surgeons reported it as prevalent in that country due to infections from rabbits.

The odd thing about it is that, although the disease was discovered and diagnosed among the ground-squirrels in California as early as 1911, not a single case in a human being has as yet been reported from that state, according to Dr. Francis, who is an authority on the disease. Is it the climate of the Golden State acting in a new rôle?

A Case of Cause and Effect

For many years the unaccountable ebb and flow in numbers of the wild rabbits in several localities has been observed by biologists and sportsmen. For a few years cottontails will be very plentiful. Then suddenly, for no known reason, there is a notable scarcity of them and hunters return with empty game bags.

On one of the national forests in a northern state, snowshoe rabbits were becoming so numerous and so far-reaching were their ravages on the young pine seedlings which the government foresters were nursing along towards saw logs that a campaign of elimination was about to be inaugurated in order to save the trees. About that time the forest rangers began to note an unaccountable scarcity of these rabbits. As the scarcity became more and more evident the foresters thanked a kindly providence for some unknown influences that saved them from the thankless and decidedly unpopular task of killing the rabbits off.

In several western states the long-legged, long-eared jacks accumulated in such vast numbers that the settlers were demanding that a bounty be paid by the state on the speedy pests as well as the holding of jack-rabbit round-ups everywhere. Before this could be done their numbers were reduced to a point where repressive measures were deemed unnecessary—all these reductions without any outward signs or reasons. Biologists now feel that the reduction in numbers was unquestionably due to tularemia, which in some manner became epidemic among the rabbits and cleaned them out, one of Dame Nature's odd ways of meeting a difficult situation.

One wonders why it would not pay the authorities in Australia to import a few thousand American bunnies and see what effect it would have on the immense numbers of rabbits that cause such heavy losses to farmers and stockmen down that way, even after the expenditure of millions of dollars, year after year, in various ways calculated to discourage large families and long life among rabbits in that country. Perhaps here is the cure for their troubles.

Deaths from Tularemia

A large number of cases of tularemia in humans have been reported from various parts of the United States. Out of five hundred listed cases, where the disease was diagnosed with certainty, twenty died—a 4 per cent. loss, which is a sufficiently high death-rate to classify tularemia as a serious matter.

If the suffering, expense and loss of time is taken into consideration, it becomes even more serious. Few recover quickly. It is generally a matter of from four to six weeks away from work or business. Out of a family of four, Dr. Francis reported that three died. Out of 311 cases investigated in one year, 235 were males, seventy-six females. Out of 420 reported cases from various parts of the south, only eighteen were Negroes. Out of these 420 cases, seventeen, or 4 per cent., terminated fatally.

Sources of Infection

While the large percentage of cases have come from handling wild rabbits, which is far and away the most dangerous source of infection, a number of infections have come from other animals.

Nearly all the squirrel and rodent families have been found guilty, while it occasionally has been definitely traced to the bites of some of the common domestic animals, such as dogs, cats and, in one case, a hog. These animals, however, undoubtedly became infected in their mouths through eating diseased rabbits.

Francis reports only one known case of the transmission of the disease from human to human. This was where a mother dressing an ulcer on her son suffering from tularemia accidentally pricked her thumb with a pin, thus carrying the infection to her own blood.

Practically every investigator who has studied the disease and made examinations of diseased rabbits or guinea-pigs through post-mortems has contracted it. No deaths have followed among them however.

It was believed at first that rubber gloves were a satisfactory safeguard. The trouble has occurred, however, when rubber gloves and every other precaution were taken against it.

The insidious nature of the infection can be best understood when it is known that a few drops of fluid from an infected rabbit have been placed on the palm of a man's hand on which there was no observable injury to or break in the skin and the man came down with tularemia inside of a week.

To date, no protective vaccine or serum has been discovered, nor has there been developed any drug that is of use in alleviating the sufferings of victims of tularemia. It seems to be a disease in which man is practically helpless and nature must be allowed to work out her own unchecked processes.

Once Sick Always Immune

It has been proven conclusively, however, that sufferers who recover are always immune to future infections and can handle diseased rabbits without danger. Nevertheless, Dr. Francis and his assistants in the Public Health Laboratory who have nearly all contracted tularemia take no chances in handling the hundreds of rabbits and guinea-pigs they have there in various stages of the disease. So far, the trouble is confined wholly to wild rabbits. No cases have ever been reported among tame rabbits, such as Belgian hares raised in rabbitries.

Spread of Disease

A study of the development of tularemia indicates rather clearly that it has spread with considerable speed all over the country. In all probability its origin will eventually be traced to the ground-squirrels of the Pacific coast. From there it has probably been carried by shipments of diseased rabbits to different parts of the country, alive and dead. The wild jacks captured in countless numbers by drives all over the west have been shipped to various sections of the country as food, for both humans and animals.

Again, great numbers of the ordinary cottontail rabbits are shipped constantly from such western states as Kansas and Nebraska to almost every eastern state to restock hunting areas, farms and estates for sporting purposes. Over fifty thousand cottontail rabbits were imported into one single eastern state from the west in 1927 to stock such areas. Quite as many more were sent to the same state for feeding foxes on large fox farms. Is it any wonder the disease has spread?

Many Rabbit Hunters

The state game warden of Pennsylvania recently stated that of the six hundred thousand licensed hunters in that state probably 80 per cent. were rabbit

hunters. In the southern states, where little Peter Rabbit is a welcome addition to the family menu, the percentage is undoubtedly even higher.

How to Recognize the Disease

If you are anxious to see whether or not a certain rabbit has tularemia, examine its liver and spleen. If these organs are covered with small white specks about the size of a pinhead, it had tularemia. These spots are the one unfailing test of the disease. Lacking them, the rabbit is probably perfectly healthy. Rabbit meat when cooked may be eaten without any danger, while rabbits infected with the disease if held in a frozen state for thirty days are perfectly harmless when cooked and eaten.

"Most of the cases among humans," according to Dr. Francis, "are self-inoculated. A market man skins and prepares rabbits for his patrons. A wife or servant dresses one for the family meal. A hunter kills one and cleans it right on the spot. A farmer pulls an infected tick from his horse, then rubs the finger in his eyes. These are the common means of infection."

Bedbugs are known to have caused the disease in guinea-pigs. Doubtless, they would also transmit it to humans.

Taking it all around, this disease seems to be one that is here to stay. It probably has been with us for many years, but until recently was not recognized in its true character.

Millions of cottontail or jack-rabbits are killed as food every year and the loss to the public, if they are not to be eaten, will run up into large figures.

On the other hand, the losses to the individual that follow the attack—the losses in time, and costs of doctors' bills—will far overrun the loss of meat. The worst of it all is that a young cottontail properly cooked is just about the most toothsome morsel in the way of game that the average American can secure.

It is but fair to explain, however, that only a small percentage of the rabbits offered for sale in the public markets are affected by tularemia. For example, Dr. Francis examined the livers of one thousand rabbits offered for sale at the various markets in the city of Washington and only found nine, or slightly less than one per cent., infected with the disease. At the same time, out of twenty-two local patients suffering with tularemia every single one had handled or dressed wild rabbits shortly before his sickness.

It will be hard to wean our people away from the use of rabbit meat. Millions will "take a chance" and use it. More's the pity; they will doubtless be the poorer classes, ignorant of the danger they are running and who also can ill afford the loss of time and the expense due to sickness.

A Few Don'ts

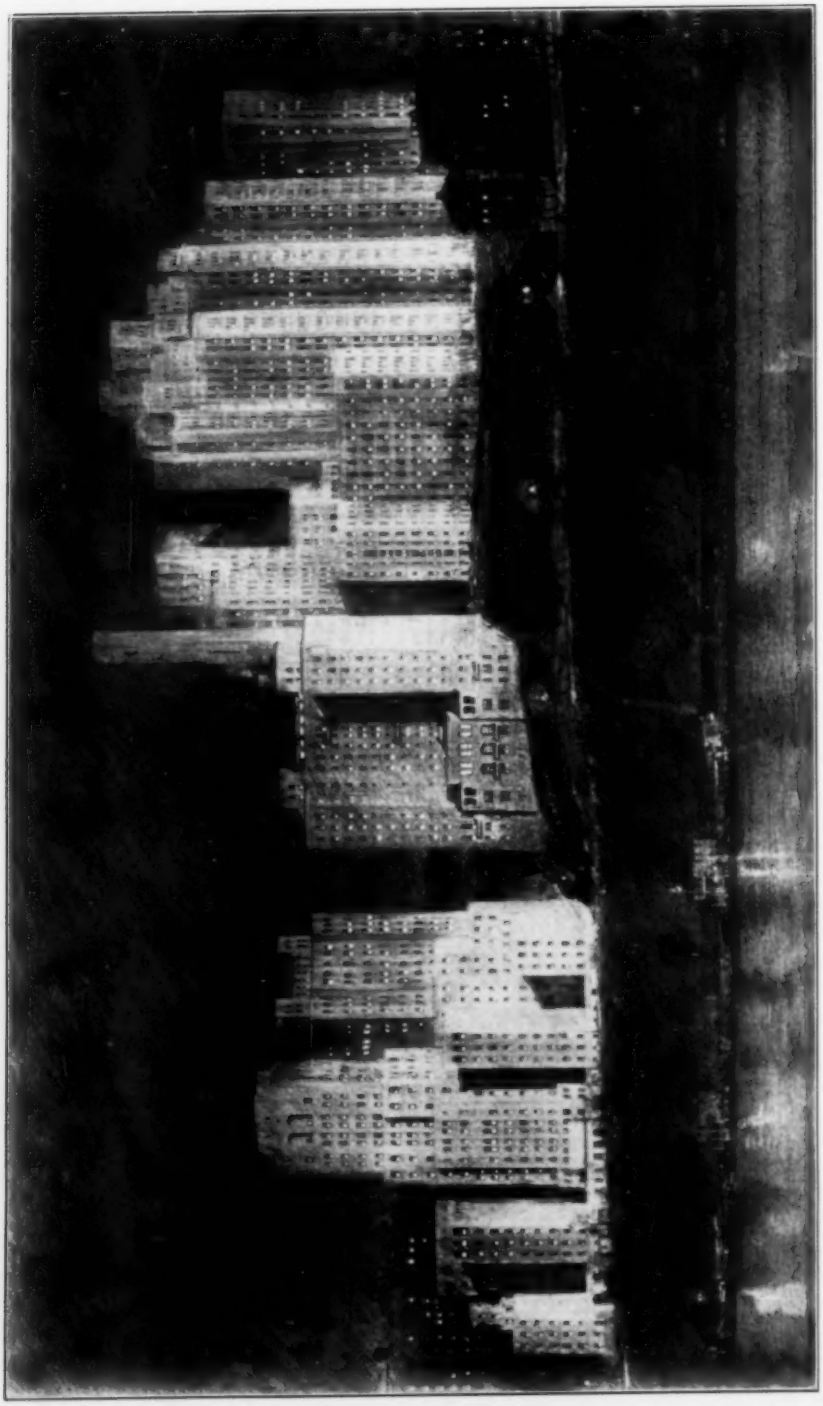
Don't touch or use a wild rabbit that seems dull, dopey, glassy-eyed, slow-moving or with rough, ragged fur.

Don't fail to shoot such rabbits or those that won't run from you on sight. When killed, either burn or bury them, lest dogs or cats contract the disease by eating the carcass.

Don't use a rabbit or handle one caught or killed and brought home by the children or family dog. They were probably too sick to run from them.

Don't handle or touch a wild rabbit, unless with rubber gloves. Even then, carefully disinfect your hands afterwards.

And finally, if you have been doing any of these "don'ts" and a few days later, out of a clear sky, suddenly develop a frightful headache, are racked with pains in every bone, your temperature is high, with frequent chills, there is a huge swelling under an armpit, and you feel sick and miserable all over, go to bed and send for the doctor. Ten to one he will find you have tularemia.



Underwood and Underwood

THE MEDICAL CENTER AT NIGHT

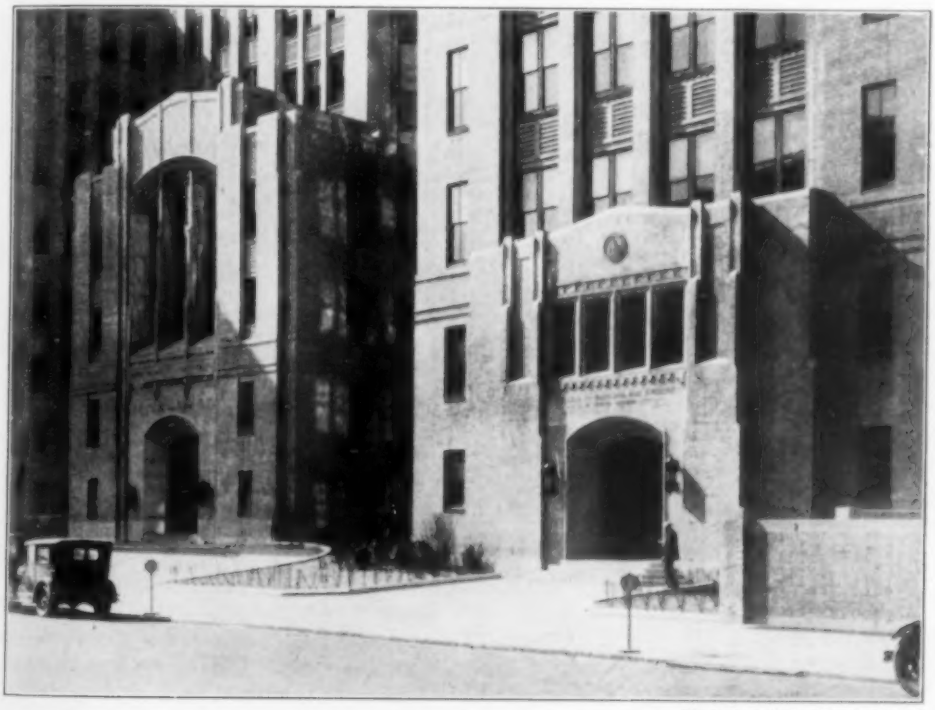
THE BUILDING AT THE EXTREME LEFT IS THE NEW YORK STATE PSYCHIATRIC INSTITUTE AND HOSPITAL; THE NEUROLOGICAL INSTITUTE IS NEXT, THEN THE ANNA C. MAXWELL HALL, THE RESIDENCE OF THE PRESBYTERIAN HOSPITAL TRAINING SCHOOL. THE GROUP BUILDING ON THE RIGHT HOUSES THE STEPHEN V. HARKNESS PAVILION; THE COLLEGE OF PHYSICIANS AND SURGEONS; THE PRESBYTERIAN HOSPITAL; THE SLOANE HOSPITAL FOR WOMEN; THE SQUIER UROLOGICAL CLINIC; THE BABIES' HOSPITAL; THE VANDERBILT CLINIC AND THE SCHOOL OF DENTAL AND ORAL SURGERY.

THE PROGRESS OF SCIENCE

THE MEDICAL CENTER OF NEW YORK CITY
A THREE-FOLD ACHIEVEMENT IN COOPERATION

Research—teaching—the care of the sick—these three fundamentals of modern scientific medicine have now been brought together and unified at the Medical Center. Towering above the Hudson, an architectural landmark even in a city of skyscrapers, the Medical Center has been functioning since early spring as a hospital, but not until the present fall term has it entered upon its work as a medical university and as a great research laboratory.

The formal dedication to its three-fold purpose on October 12, with academic procession and the conferring of honorary degrees on citizens identified with the movement—Messrs. Edward F. Harkness, Dean Sage, James Gamble Rogers and Otto Marc Eidlitz—celebrated an accomplished fact, no longer a "project." For with the installation within its walls of the College of Physicians and Surgeons, the De Lamar Institute of Public Health, the School of Dental and Oral Surgery and the School of Oral Hygiene—teaching groups of Columbia University—the Medical Center had definitely rounded out its



—Photograph by R. S. Grant

ENTRANCES TO THE MAIN BUILDINGS

SHOWING CLEARLY THE JUXTAPOSITIONS OF THE ASSOCIATE INSTITUTION. THE ENTRANCE ON THE LEFT IS THAT OF THE PRESBYTERIAN HOSPITAL, THE SLOANE HOSPITAL FOR WOMEN, AND THE SQUIER UROLOGICAL CLINIC. THE ENTRANCE ON THE RIGHT IS TO THE COLLEGE OF PHYSICIANS AND SURGEONS AND THE VANDERBILT CLINIC.

Underwood and Underwood

THE LIBRARY OF THE COLLEGE OF PHYSICIANS AND SURGEONS.

functions, becoming an educational institution for advanced study and research, as well as a unique assemblage of hospitals and clinics. The advantages which accrue—on the one hand to the patient, on the other to faculty and students—from this proximity and interrelationship of hospital, clinic, school and laboratory are self-evident and far-reaching.

Of special interest from a professional viewpoint is the fact that for the first time in New York City are now brought together in one building a dental school and a medical school, with their students having many courses in common. This marks a distinct step toward an ideal long held by leaders in dentistry —the recognition of this science as a department of medicine and the establishment of standards of dental teaching comparable to those of medicine.

That groups for study and research in dietetics, in nursing, and in social service are also housed at the Medical Center emphasizes anew its significance as a great cooperative achievement, a significance repeatedly stressed in the recent ceremonies, both by word of mouth and by the personnel of participants and guests, representing many fields of scientific and educational endeavor.

Appropriately, the address of dedication was delivered by Dr. Samuel W. Lambert, dean emeritus of the College of Physicians and Surgeons, and president of the New York Academy of Medicine. His association with the Medical Center movement goes back eighteen years to the time when Columbia University and the Presbyterian Hospital first entered into an agreement whereby the latter became the teaching hospital for the College of Physicians and Surgeons. From that beginning

OPERATING AMPHITHEATER, WITH 149 SEATS

THERE IS A RADIO PHONE ATTACHED TO EACH SEAT SO THAT THE HEART BEAT OF THE PATIENT ON THE TABLE CAN BE PLAINLY HEARD BY THE STUDENT. ONE OF THE FEATURES OF THIS OPERATING ROOM IS THE X-RAY VIEWING MACHINE SO THAT THE SPECTATORS CAN FOLLOW THE OPERATION AS IT PROGRESSES. THE TILING IN THIS ROOM IS GREEN. THIS DOES AWAY WITH GLARE AND IS EASIER ON THE EYES OF THE ATTENDING PHYSICIANS.

came ten years later the formation of the Joint Administration Board to organize a complete Medical Center.

To-day the cooperating institutions include, besides the teaching groups already mentioned, the New York State Psychiatric Institute and Hospital, Presbyterian Hospital of New York, Presbyterian Hospital School of Nursing, Squier Urological Clinic, Harkness Private Pavilion, Neurological Institute of New York, Babies' Hospital of New York, Sloane Hospital for Women and the Vanderbilt Clinic. Each of the units retains its identity while cooperating in the purposes of the center. And all are now housed on its twenty-acre campus with the exception of the New York State Psychiatric Institute, the Babies' Hospital and the Neurological Institute whose buildings are under construction.

That the Medical Center, while functioning in its threefold aspect, is by no means a finished project, lends an enduring and forward-looking interest to its activities. Not only has space been allotted for the expansion of the present buildings and for projected residences and recreational halls for the staff, but there is also provision for additional buildings which may be called for by future discoveries and development in science. To open doors of opportunity for coming generations has been the object of its planners—as well as to make the maximum contribution to the welfare of the present. For these ends, the perfection of its buildings and equipment, outstanding as are both, is secondary to the idea which they represent—the union of all the elements of medicine and related sciences for the benefit of mankind—along the three lines of endeavor, teaching, research and the care of the sick.

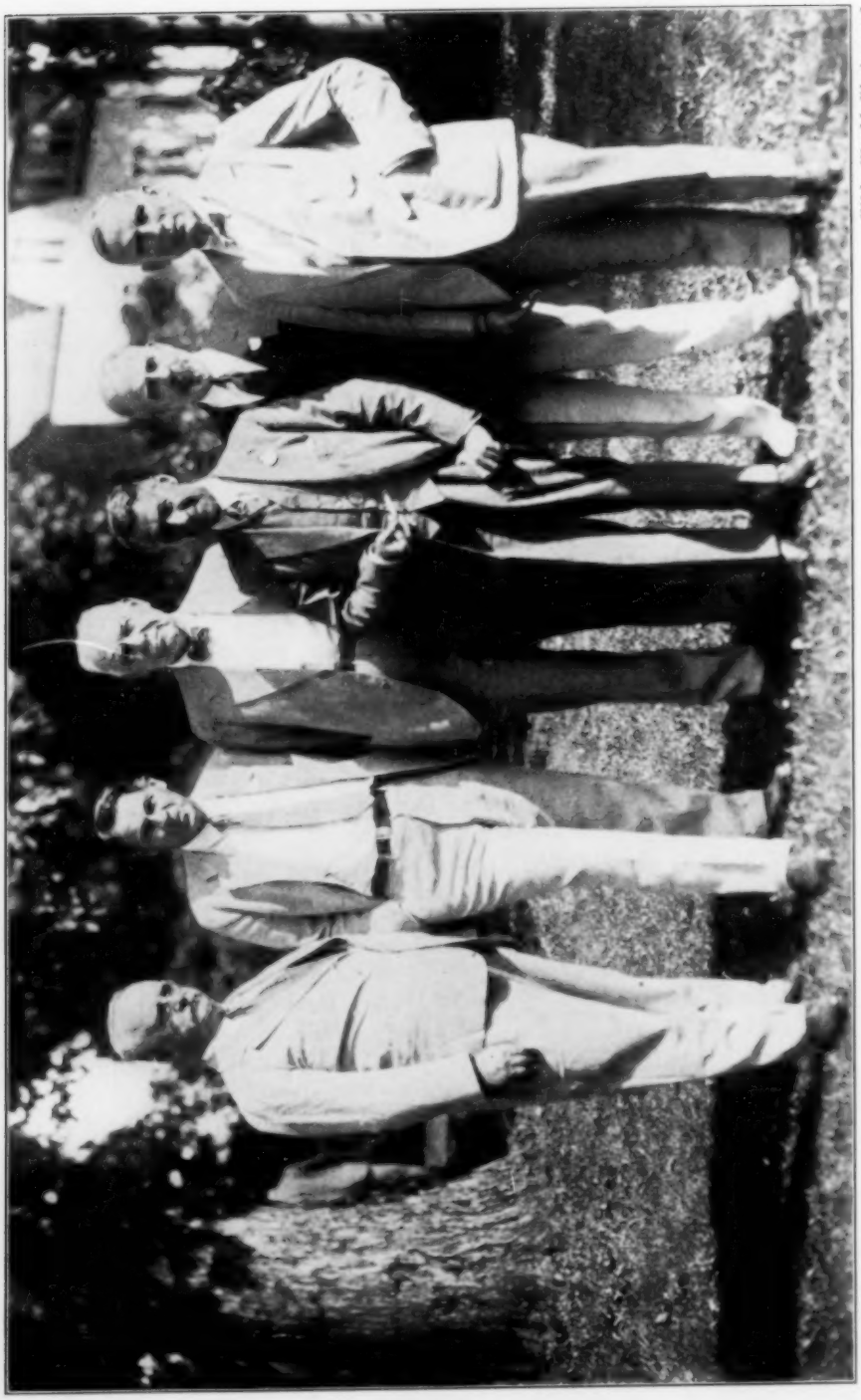
THE INSTITUTE OF CHEMISTRY

THE second session of the Institute of Chemistry of the American Chemical Society concluded its four weeks' session on August eighteenth at Northwestern University, Evanston, Illinois. It will be recalled that the first session was held at State College, Pennsylvania, in 1927, where four hundred and fifteen were registered for the various sessions. The second session had a registration of six hundred and thirty three, not including those who attended single lectures. Of these the majority came from industry, only one hundred and fifty-five being identified with the teaching profession. A large number attended single lectures, and in addition the public was welcomed to the less technical lectures of the evening.

The plan of the Institute is to provide programs to engage the entire time of those so inclined, but composed of units to enable those who wish to combine recreation with their institute activities to take as little or as much of each day's offering as he may care to without losing continuity of thought or argument as would otherwise be the case. The effort is also made to so arrange the program as to serve the needs of chemists of various experience. In particular, the institute is a place where the present status of special fields in the science may be related by those expert in those fields, and where discussion may go on leisurely in the absence of crowded programs or too diverse attractions.

Geographically, people came from nearly every state in the Union, from Canada, Scotland, Norway and the Philippines.

The program, while not neglecting theoretical chemistry, nevertheless tended to emphasize applied chemistry. The first week was especially devoted to agricultural problems having a chemical approach. On each of five evenings



Wide World Photograph

SOME OF THE DISTINGUISHED CHEMISTS PRESENT AT THE MEETINGS

AT THE SESSION. L. TO R., CHARLES L. PARSONS, SECRETARY OF AMERICAN CHEMICAL SOCIETY; H. N. HOLMES, PROFESSOR AT OBERLIN COLLEGE; S. W. PARR, PRESIDENT, A. C. S.; SIR JAMES IRVINE, PRINCIPAL OF THE UNIVERSITY OF ST. ANDREWS, SCOTLAND; H. E. HOWE, EDITOR OF *Industrial and Engineering Chemistry*, AND C. M. ROMMEL, OF THE U. S. DEPARTMENT OF AGRICULTURE.

Wide World Photograph

SIR JAMES IRVINE

GUEST OF HONOR AT THE SESSION OF THE INSTITUTE OF CHEMISTRY.

Industrial and Engineering Chemistry, AND G. M. ROMANCE, OF THE U. S. DEPARTMENT OF AGRICULTURE.

of the week motion picture programs were offered, followed by a popular lecture. Special industrial trips were taken to the Argo plant of the Corn Products Refining Company, to the North Side and Des Plaines sewage treatment works of the city of Chicago, Sherwin-Williams Company, Universal Portland Cement Company, the Whiting refinery of the Standard Oil Company of Indiana, the laboratory of the Universal Oil Products Company at Riverside, Illinois, and the Hawthorne Works of the Western Electric Company. A party of forty-five were the guests of E. B. Frost, director of the Yerkes Observatory, on one of the Sundays.

Recreation was not overlooked in an otherwise heavy program, and many enjoyed golf, tennis and swimming. Each evening an informal mixer or social gathering was held at Willard Hall, and on these occasions in addition to popular diversions there were informal discussions and motion pictures as well as special talks on several occasions. These included a vivid portrayal of the life at St. Andrews by Sir James C. Irvine, the honor guest of the institute, a discussion of the problems of a chemistry teacher in China by Earl Otto who served for four years as a teacher in the Orient and the recitation of Anglo-Norwegian dialect poems by Louis N. Crill, secretary of agriculture of South Dakota.

The scheduled speakers numbered one hundred and eighteen and some of these appeared more than once on the program, besides broadcasting radio talks over WGN and appearing upon request before several luncheon clubs and other organizations in the vicinity of Evanston and Chicago. The sessions attracted the attention of the daily press, through which many thousands had awakened a new interest in chemistry in its several relations to everyday affairs.

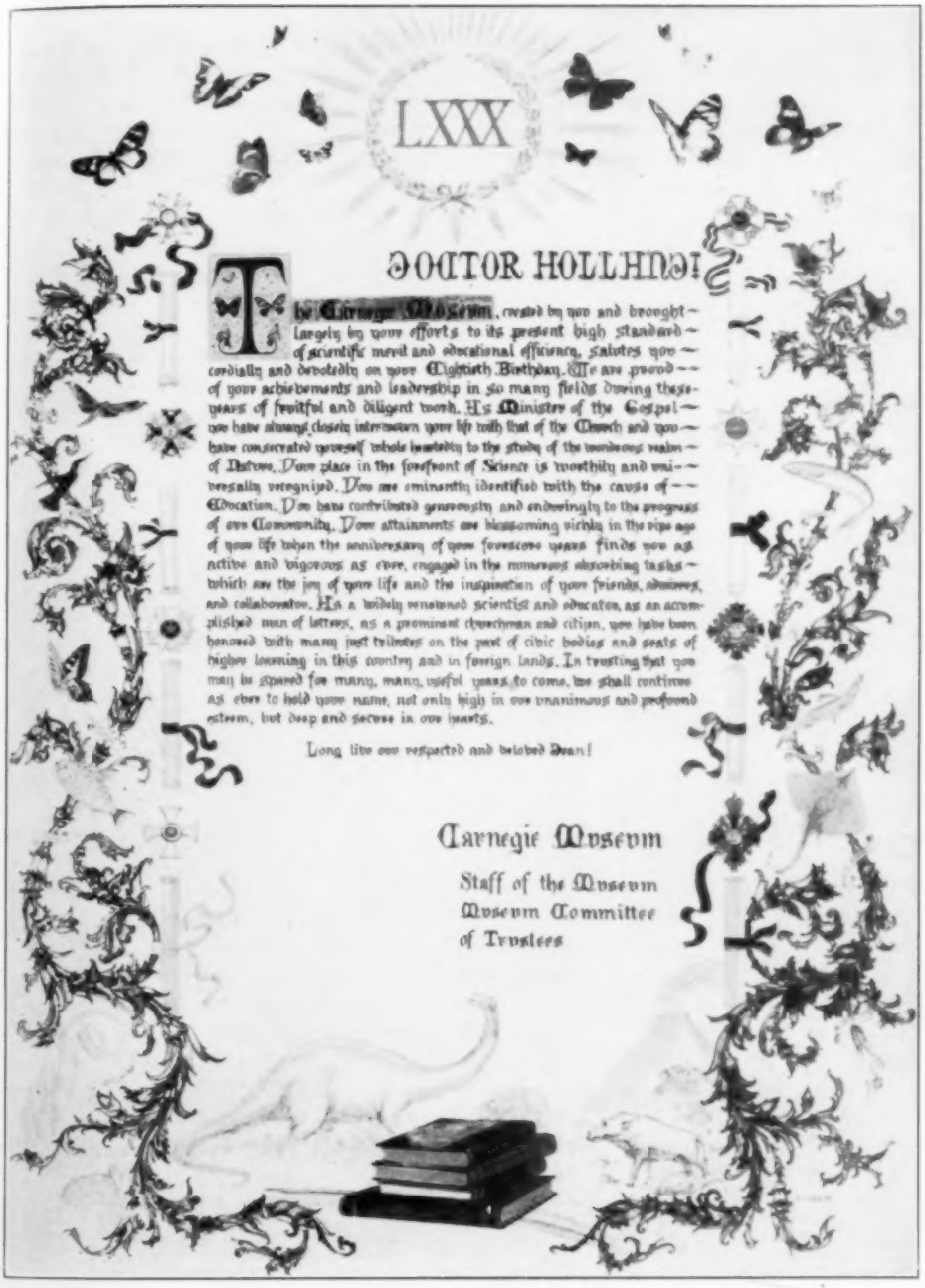
It is yet to be determined whether the institute will hold a third session in 1929, the first two being the only ones thus far authorized by the Council of the American Chemical Society. The future of the institute came before the Council at the seventy-sixth meeting of the society held at Swampscott, Massachusetts, from September 10 to 14, 1928. It will also be necessary to find financial support if the experiment is to continue and be developed into a permanent annual activity.

ULTRA-SOUND WAVES IN BIOLOGY

Dr. E. Newton Harvey, professor of physiology at Princeton University, and Alfred E. Loomis, of the Loomis Laboratory, of Tuxedo Park, New York, are producing, and applying to biological research, supersonic waves which oscillate so rapidly that they can not be heard by the human ear.

When a flat disc cut from a quartz crystal is compressed in a certain direction with reference to the crystal axis, one side will become charged positively, and the opposite side will become negatively charged. This is the piezo-electric effect. Conversely, if the crystal disc is placed between two plates properly charged, the crystal will be compressed. On reversing the charges the crystal expands. The compressions and expansions travel through media in contact with the crystal as sound waves which may be given very high frequencies by the proper oscillating device. Each crystal disc has a natural vibration period of its own, depending on its thickness.

The supersonic waves—the ultra-violet of sound—are produced by a miniature radio broadcasting apparatus which causes the quartz crystal to vibrate. The apparatus is operated on 110-volt alternating current and em-


LXXX
DOCTOR HOLLAND
To the Carnegie Museum, created by you and brought largely by your efforts to its present high standard of scientific merit and educational efficiency, salutes you cordially and devotedly on your Eightieth Birthday. We are proud of your achievements and leadership in so many fields during these years of fruitful and diligent work. As Minister of the Gospel you have always closely interwoven your life with that of the Church and you have consecrated yourself wholeheartedly to the study of the wonderous realm of Nature. Your place in the forefront of Science is worthily and universally recognized. You are eminently identified with the cause of Education. You have contributed generously and endowingly to the progress of our Community. Your attainments are blossoming virility in the ripe age of your life when the anniversary of your fourscore years finds you as active and vigorous as ever, engaged in the numerous absorbing tasks which are the joy of your life and the inspiration of your friends, admirers, and collaborators. As a widely venerated scientist and educator, as an accomplished man of letters, as a prominent churchman and citizen, you have been honored with many just tributes on the part of civic bodies and seats of higher learning in this country and in foreign lands. In trusting that you may be spared for many, many, useful years to come, we shall continue as ever to hold your name, not only high in our unanimous and profound esteem, but deep and secure in our hearts.
Long live our respected and beloved Dean!
Carnegie Museum
Staff of the Museum
Museum Committee
of Trustees

TRIBUTE TO DR. HOLLAND

ILLUMINATED MANUSCRIPT PRESENTED BY THE CARNEGIE MUSEUM TO DR. W. J. HOLLAND ON THE OCCASION OF HIS EIGHTIETH BIRTHDAY WHICH OCCURRED ON AUGUST 16, DURING THE SESSIONS OF THE FOURTH INTERNATIONAL ENTOMOLOGICAL CONGRESS AT ITHACA.

ploys a 75-watt tube with two small transformers. The apparatus has been so devised that the quartz crystal, the producer of the supersonic waves, can be placed on the stage of a microscope with the specimen to be studied above it in the direct path of the waves. In this way it has been possible for the first time to examine the effect of the ultra-sound waves upon cells.

The characterization of high-frequency sound waves (or supersonics) as the "ultra-violet of sound" is an indication of the relationship which these bear to the sound waves we more frequently encounter. The two departures from the ultra-violet—to spoil the analogy as early as possible—must not be lost sight of. They do not pass through a vacuum (which emphasizes their chief relationship to ordinary sound waves) and apparently they do not stimulate specialized tissues like muscle and nerve. In this latter respect they differ from certain bands of the electromagnetic spectrum (*e.g.*, radiant energy and electricity). But one wonders whether some sensitization will not be effected so that it is possible to stimulate sensory tissues, ere the task is done. Two frequencies have been used—400,000 and 1,200,000 vibrations per second.

Observing under a high-power microscope, it has been possible to follow the progressive destruction of frog blood corpuscles. The oval cells at first become warped and twisted. Strained areas appear and the color fades, leaving a pale distorted shadow. Individual bacteria can be studied, but while they can be violently agitated their destruction under the microscope has not been observed.

If a fine emulsion of oil is examined an individual droplet of oil can be singled out and made to rotate rapidly in either direction at speeds that can be accurately controlled by varying slightly the frequency of the oscillating circuit.

An excellent material to illustrate the effects of these waves is a leaf of Elodea, which is two cell layers thick. The protoplasm with suspended chloroplasts forms a thin layer about the cellulose cell wall enclosing the vacuole of cell sap. High-frequency sound waves of low intensity passed through these cells cause the protoplasm to rotate very much as in the normal rotation or cyclosis of Elodea. Increasing the intensity increases the movement until the whole cell is a rapidly whirling mass of protoplasm, fragments of which are torn loose and rotate as small balls in the vacuole. The effect is very striking and might almost lead one to conclude that the normal cyclosis of this plant was caused by high-frequency vibrations. The normal protoplasmic rotation of Elodea is stopped by the waves unless they are of very low intensity. Rotation begins again provided the raying has not been too strong. Sugar plasmolysed Elodea cells are affected in the same manner as are the unplasmolysed ones, the whole protoplasm rotating rapidly, until, with increasing intensity, the mass finally bursts and scatters the chloroplasts, still whirling, throughout the cell. Nitella cells when rayed have the chloroplasts torn from the walls of the cell and whirled rapidly, leaving a clear area which had originally been a uniform green color.

No effects of the waves have been noted that could be clearly traced to an influence on chemical processes in cells, although it is known that high intensity waves influence certain chemical systems, especially metastable ones. The phenomena in living organisms, apart from temperature rise, are connected with mechanical effects, the most striking of which might be best described as "intracellular stirring."

FRESH DISCOVERIES IN MAYA EXPLORATION

The results of the Maya exploration work of the Carnegie Institution of Washington were described at the International Congress of Americanists in September. Dr. A. V. Kidder, Dr. S. G. Morley and other members of the archeological staff presented reports covering a season which has thrown fresh light upon that remarkable race of aborigines which the New World developed. Two events in particular stamp the 1928 working season as having been one of unusual richness—the excavation of Pyramid E-VII at Uaxactun (Wah-shawk-toon), Guatemala, and the discovery of an ancient ceremonial treasure in the Temple of Warriors at Chichen Itzá, Yucatan.

Some two thousand years ago the inhabitants of a distant city in what is now the northernmost department of the Republic of Guatemala built a wonderful pyramid.

This pyramid, 85 feet square at the base and 25 feet high, was ascended by four stairways, one on each side. Colossal masks of fine lime stucco, the upper pairs fashioned in the likeness of grotesque human heads, the lower pairs after the manner of serpents' heads, flank these stairways and, like grim sentinels, guard the approaches to the holy region above.

Time passed. Probably very near the beginning of the Christian era this beautiful pyramid, built of uncut stone,

ANCIENT MAYA TEMPLE

AT UAXACTUN (WAH-SHAWK-TOON), GUATEMALA, UNCOVERED BY THE CARNEGIE INSTITUTION OF WASHINGTON. THE SUMMIT IS REACHED BY FOUR STAIRWAYS, EACH FLANKED BY COLOSSAL MASKS OF FINE LIME STUCCO, THE UPPER PAIRS REPRESENTING GROTESQUE HUMAN HEADS, THE LOWER PAIRS FASHIONED AFTER THE MANNER OF SERPENTS' HEADS.

and faced with dazzling white stucco was covered up, completely buried by the ancient inhabitants of the city. They built around it and over it a covering of rough rubble which, while it completely concealed the original pyramid, doubled the height of the new pyramid and also increased the area it covered.

Time and the growth of forest trees had almost completely destroyed its exterior finish, but enough remained to show that it had been a very steep structure some 50 feet high. Evidence is at hand to indicate that the new pyramid was used as the point of observation in a gigantic sun dial by means of which the positions of the equinoxes and solstices were determined for priests and people. Why the older and probably more beautiful pyramid was covered up and completely hidden, however, still remains an archeological mystery.

The original pyramid is perhaps one of the most beautiful examples of ancient American architecture that has come down to us. Its harmonious proportions, its pleasing silhouette, its dignified bearing, its dazzling silvery white finish, make it one of the most satisfying pictures of the past to be found anywhere in the world.

The top of the earlier pyramid is covered with a floor of hard white plaster painted a deep red. As this shows no traces of walls, or of any superstructure, one is forced to the conclusion that no building had ever surmounted it. It would seem to have been a place of sacrifice, a holy place in a very real sense.

In the coarse rubble forming the hearting of the apex three cysts were found, one of which was a grave of large, cut, untrimmed stones and mud. The grave contained the headless skeleton of a female, whose age was estimated at twenty-five, which lay fully extended, face down, the feet towards the west. Another cyst contained six pots, three of which were of plain red ware with flaring rims and three of plain brown ware with covers. The vessels were protected from the weight of the superimposed earth by large stones. The third cyst also contained pottery in which various articles were found, such as seeds, shells, dried gummy materials, pieces of obsidian, and an obsidian lancet, extremely sharp and well-made.

Three hieroglyphic stone monuments in the plaza of the ancient city were found to have been erected at the same time, and two of these have the very early Maya date 8.16.0.0.0, corresponding to 97 A. D., inscribed upon them. How much older than this date the earlier stucco pyramid may be, it is impossible to say. It would seem reasonable to suppose that at the time it was covered up it had been in use a century or more. If 97 A. D. marks the date when the older temple was covered, as is probable, then 2,000 years is not far from the real age of the original structure.

Having been in good repair when it was entombed by the erection of the secondary pyramid, and having been protected by the latter through the centuries, the primary pyramid, judged as a whole, may be said to be in practically the condition it was in when it was buried 2,000 years ago.

We wish to acknowledge our obligations to The American Geographical Society for the loan of the map of the Arctic Basin from "Problems of Polar Research," which appeared in the September number of The Scientific Monthly, and for the cuts from Professor Davis' book entitled "The Coral Reef Problem," which accompanied his article in the number for October. We regret that the credit line was accidentally omitted when these illustrations were printed.